EXHIBIT 2

Redacted Pursuant to February 27, 2019 Order

UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF NEW YORK

IN RE FOREIGN EXCHANGE BENCHMARK RATES ANTITRUST LITIGATION

No. 1: 13-cv-7789-LGS

Expert Report of Prof. Justin McCrary

October 25, 2018

Redacted Pursuant to February 27, 2019 Order

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I. Qualifications

1. I am an economist with expertise in economic modeling, statistical methods, and law and economics, among other subjects. I received my A.B. in Public Policy from Princeton University in 1996. After working at National Economics Research Associates in White Plains, New York, and the Federal Reserve Bank of New York from 1996 to 1998, I began my Ph.D. in Economics at the University of California, Berkeley ("Berkeley"), completing the degree in June 2003. After close to five years as Assistant Professor at the University of Michigan ("Michigan"), I became Assistant Professor of Law at Berkeley in January 2008 and was promoted to Professor of Law in July 2010. In Fall 2017, I took leave from Berkeley and assumed a position as the Samuel Rubin Visiting Professor of Law at the law school of Columbia University ("Columbia"). In July 2018, I joined the Columbia faculty on a permanent basis as the Paul J. Evanson Professor of Law.

2. At Michigan, I taught courses on introductory statistics and advanced microeconomic theory to M.P.P. students, and advanced econometric theory to Ph.D. students. At Berkeley, I taught courses on introductory, intermediate, and advanced statistics to J.D., L.L.M., and Ph.D. students; law and economics to J.D. students and undergraduates; labor economics to Ph.D. students in economics and in other fields; and business law to J.D., L.L.M., and M.B.A. students. At Columbia, I teach corporations law, antitrust, and law and economics.

3. In addition to my post as Professor of Law at Berkeley, I served as the Founding Director of D-Lab, the Social Sciences Data Laboratory at Berkeley, from July 2014 to June 2017, at which point I stepped down to visit Columbia. At D-Lab, I lectured on and advised graduate students and faculty regarding high-performance computing, statistical software, and statistical techniques.

4. From September 2009 until July 2014, when I began to direct the D-Lab, I co-directed the Law and Economics Program at Berkeley Law. Since 2017, I have served on the Board of Directors of the American Law and Economics Association.

5. Since 2007, I have co-directed the Economics of Crime Working Group of the National Bureau of Economic Research ("NBER"). The NBER is the preeminent professional association of economists in the world, with over 1,400 members worldwide. I was invited to become a Faculty Research Fellow of the NBER in 2006 and remained in that position until 2012, when I was invited to become a Faculty Research Associate.

6. My research spans a diverse range of topics, including econometric and statistical methodology, antitrust, crime, employment discrimination, education, fertility, financial markets, income inequality, and monetary policy. I have published 18 papers, many of them in leading journals within economics, such as the *American Economic Review*, the *Review of Economics and Statistics*, the *Journal of Economic Literature*, and the *Journal of Econometrics*. One publication, "Manipulation of the Running Variable in the Regression Discontinuity Design," published in the *Journal of Econometrics*, has been cited over 2,000 times in the academic literature according to Google Scholar. Six other papers have been cited over 100 times according to Google Scholar.

7. In addition to my published papers, I am a co-editor of the book *Controlling Crime: Strategies and Tradeoffs*, published by the University of Chicago Press. Over the years, my research has been supported by Michigan, Berkeley, the MacArthur Foundation, the NBER, the National Institutes of Health, the National Science Foundation, the Arnold Foundation, and the Robert Wood Johnson Foundation.

8. I regularly review articles for the leading peer reviewed journals within economics, including *Econometrica*, the *American Economic Review*, the *Quarterly Journal of Economics*, the *Journal of Political Economy*, the *Review of Economic Studies*, the *Journal of Econometrics*, the *Review of Economics and Statistics*, and the *American Law and Economics Review*. Peer review specifically focuses on assessing whether submitted manuscripts are employing methodologies that are consistent with academic standards.

9. My consulting experience has spanned a wide range of industries and markets, with many involving the study and use of economics, econometrics, and statistics. In addition to work as a consultant for companies, I often provide consulting for the federal, state, and local governments, frequently on a *pro bono* basis. These engagements have included clients such as the Attorney General of the State of California, the City of Chicago, the City of Oakland, the City of San Bernardino, the City of Stockton, the State of Delaware, the Pennsylvania State Troopers Association, the U.S. Department of Justice, the U.S. District Court for the Southern District of New York, and the U.S. Equal Employment Opportunity Commission. All of these engagements have involved the study and use of economics, econometrics, and statistics. A copy of my curriculum vitae, including a list of previous testimony and depositions, is included as **Appendix A**.

II. Background and Assignment

10. This matter is a class action alleging foreign exchange ("FX") market antitrust violations brought by twenty-seven entities and individuals ("Plaintiffs")[1] against sixteen defendant banks ("Defendants" or "Defendant Banks").[2] I understand from the Class Certification Memorandum that all Defendants except for Credit Suisse have settled.[3]

11. In the Complaint, Plaintiffs allege that "Defendants conspired with each other to fix prices in the FX market."[4] More specifically, Plaintiffs allege that "Defendants communicated directly with each other to coordinate their: (i) fixing of spot prices; (ii) manipulating FX benchmark rates; and (iii) exchanging key confidential customer information in an effort to trigger client stop loss orders and limit orders."[5] I understand from the Class Certification Memorandum that for "purposes of certifying their antitrust claims for trial, the Classes have focused on Defendants' conspiracy to widen FX bid-ask spreads."[6] Specifically, Plaintiffs have alleged that "Defendants agreed to fix FX prices by widening bid-ask spreads in at least 52 currency pairs."[7] In their Class Certification Memorandum, Plaintiffs assert that "Defendants persistently used interconnected multibank chat rooms to disseminate sensitive competitive information, including spreads to be made to their customers."[8] Plaintiffs propose a class period from December 1, 2007 to December 31, 2013 ("Class Period") and move to certify two classes, an "OTC Class" and an "Exchange Class."[9]

12. I have been retained by counsel for Credit Suisse Group AG, Credit Suisse AG, and Credit Suisse Securities (USA) LLC, (together, "Credit Suisse") to review and respond to the opinions related to statistical sampling, measurement and extrapolation in the expert reports

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[1] Third Consolidated Amended Class Action Complaint, *In Re Foreign Exchange Benchmark Rates Antitrust Litigation*, No. 1:13-cv-07789-LGS, Dkt. No. 619 (June 3, 2016) ("Complaint"), p. 1.

[2] Complaint, ¶¶ 47–62.

[3] Memorandum of Law in Support of Plaintiffs' Motion for Class Certification, *In Re Foreign Exchange Benchmark Rates Antitrust Litigation*, No. 1:13-cv-07789-LGS (May 31, 2018) ("Class Certification Memorandum"), pp. vii, 2.

[4] Complaint, ¶ 6.

[5] Complaint, ¶ 6.

[6] Class Certification Memorandum, p. 2.

[7] Class Certification Memorandum, p. 1.

[8] Class Certification Memorandum, p. 8.

[9] Class Certification Memorandum, p. 2. I understand that excluded from the definitions of these proposed classes are those "trades whose prices were set on the basis of benchmark rates, such as the WM/Reuters FX closing spot rates or the ECB reference rates."

by Mr. Robin Poynder and Dr. Hal J. Singer.[10] In particular, I have been asked to (1) evaluate Mr. Poynder's statistical sampling and measurement, and (2) assess Dr. Singer's proposed statistical sampling methodology and his extrapolation of Mr. Poynder's analysis from the sample to the population of trading days within the proposed Class Period.

13. In forming my opinions, in addition to the Singer Report and the Poynder Chat Report, I have also reviewed and relied upon the back-up materials for the Poynder Chat Report ("Poynder Production Materials"), the expert report of Keith Underwood,[11] academic articles, books and case-specific documents, including deposition testimony in this case. A complete list of the materials I considered can be found in **Appendix B** to this report. I understand that discovery in this matter is ongoing, and I reserve the right to update my opinions if new information is made available to me.

14. I am being compensated for my work in this matter at my standard billing rate of $850 per hour. In preparing this report, I have been assisted by staff of Cornerstone Research, who worked under my direction. I receive compensation from Cornerstone Research based on its collected staff billings for its support of me in this matter. Neither my compensation in this matter nor my compensation from Cornerstone Research is in any way contingent or based on the content of my opinion or the outcome of this or any other matter.

III. Summary of Opinions

15. In my opinion, Dr. Singer and Mr. Poynder's sampling and extrapolation methodology are not scientifically reliable. In particular, in order to reliably draw conclusions regarding the "pervasiveness" of the alleged exchanges of sensitive competitive information ("SCI") by the Defendants, Dr. Singer and Mr. Poynder's random sampling, measurement, and estimation procedure needs to comport with three pillars of statistics: (1) it needs to yield a sample that is representative of the appropriate population, (2) it needs to provide an estimate that is accurate, *e.g.*, unbiased, for the variable of interest in the population, and (3) it needs to provide an accurate quantification of the uncertainty (such as a margin of error) that is associated with that estimate and sufficiently precise. Failure to meet any one of these requirements renders the methodology unreliable. As I discuss below, Dr.

[10] Expert Report of Robin Poynder (Bank Chats), May 31, 2018 ("Poynder Chat Report"); Class Certification Report of Hal J. Singer, May 31, 2018 ("Singer Report").

[11] Expert Report of Keith Underwood, October 25, 2018 ("Underwood Report").

Singer and Mr. Poynder's sampling and measurement[12] methodology violates all three of these pillars and is therefore unreliable.

16. As an initial matter, Mr. Poynder appears to have come up with his definition of SCI *while conducting* his review of communications.[13] It is well accepted that a researcher, where possible, should pre-specify her research design and establish the "rules of the game" prior to conducting an analysis.[14] In other words, Mr. Poynder should have clearly defined what constitutes SCI *before* starting the review and should not have altered the definition of SCI *during* the review or let the definition of SCI be informed by the review. Mr. Poynder "moves the goalposts" by developing the definition of what constitutes SCI while conducting the analysis, which can introduce bias and render the results meaningless.

17. When designing and implementing a sampling and measurement methodology, it is standard practice for sampling/measuring experts to tie the sampling and measurement methodology to the purpose for which it is being used—in this case, to support Plaintiffs' theory of liability or damages. However, Plaintiffs' Experts have failed to even attempt to explain how their analyses can be used to assess the merits of Plaintiffs' theory of liability or damages in this matter.

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[12] In this report, I may refer to the review and classification (or coding) of communications undertaken by Mr. Poynder as a "measurement" or "measurement methodology."

[13] Deposition of Robin Poynder, September 27, 2018 ("Poynder Deposition"), p. 134:14–18. Mr. Poynder testified that the "definition [of SCI] was something [he] came up with through the process of doing the analysis to arrive at a convenient term that would encompass the various kinds of information that [he] was observing there."

[14] This has become a best practice to prevent researchers from potentially "moving the goalposts" as they conduct their analysis. In situations where pre-specification of the research design is not possible, the researcher needs to acknowledge this fact and account for the fact that rules are not pre-specified in her analysis. Mr. Poynder has failed to do so. "Another characteristic of the randomized experiment is that it can be described as 'pre-specified' research design. In principle, *before* the experiment is carried out, the researcher is able to dictate in advance what analyses are to be performed. Indeed, in medical research conducted in the US, prior to conducting a medical experiment, investigators will frequently post a complete description of the experiment in advance at a web site such as clincaltrials.gov. This posting includes how the randomization will be performed, the rules for selecting subjects, the outcomes that will be investigated, and what statistical tests will be performed. Among other things, such pre-announcement prevents the possibility of 'selective reporting'—reporting the results only from those trials that achieve the 'desired' result. The underlying notion motivating such procedure has been described as providing a 'severe test'—a test which 'provides an overwhelmingly good chance of revealing the presence of a specific error, if it exists—but not otherwise' (Mayo, 1996, page 7). This notion conveys the idea that convincing statistical evidence does not rely *only* on the 'fit' of the data to a particular hypothesis but on the *procedure* used to arrive at the result. Good procedures are ones that make fewer 'errors.'" DiNardo, John, and David S. Lee, "Program Evaluation and Research Designs," *Handbook of Labor Economics*, Vol. 4A, Orley Ashenfelter and David Card, eds. (Amsterdam, The Netherlands: Elsevier B.V.), 2011, p. 484.

18. Mr. Poynder's measurement methodology has not yielded an accurate or unbiased measurement of alleged SCI because Mr. Poynder has failed to provide in his report a clear, complete and objective set of rules based on which he classified the set of at-issue communications and which would allow an independent reviewer to replicate his analysis. I understand that Mr. Underwood, an expert for Credit Suisse, takes issue along multiple dimensions with Mr. Poynder's definition of what constitutes alleged exchanges of SCI. In particular, Mr. Underwood points out that "the exchange of market information in chat rooms could benefit customers by facilitating efficient risk management by the liquidity providers which may, under certain circumstances, be translated into narrower spreads" and that Mr. Poynder "failed to consider whether communications were appropriate under industry standards such as the *FX Global Code*."[15] Mr. Underwood also noted mistakes in Mr. Poynder's classification, and, finally, Mr. Underwood has come to different conclusions when reviewing certain of the at-issue communications.[16] Several choices Mr. Poynder made in his classification methodology seem at odds with Plaintiffs' allegations and their theory of liability or damages. As pointed out by Mr. Underwood, Mr. Poynder has further stated that he has not rendered any judgment regarding the appropriateness of the alleged information shared by traders.[17] In other words, Mr. Poynder has very likely classified certain communications as exchanges of SCI, even though they may well be consistent with current and historical industry standards. In addition, Mr. Poynder has testified that he would have counted instances in which traders discussed *narrowing* spreads to customers as SCI,[18] but he has failed to explain what relevance such an inclusion has, given Plaintiffs' allegation of a conspiracy involving the *widening* of spreads by Defendants. Because Mr. Poynder failed to provide a clear and objective set of rules based on which he classified the at-issue communications, it is likely an independent reviewer would come to different conclusions upon reviewing the same communications as Mr. Poynder. To the extent disagreement exists among independent reviewers, Dr. Singer's estimates, which are based on Mr. Poynder's results, could be biased and his quantification of uncertainty associated with his estimates

[15] Underwood Report, ¶¶ 61, 63.

[16] Underwood Report, ¶¶ 16–19.

[17] Underwood Report, ¶ 63.

[18] Poynder Deposition, pp. 138:7–139:16. He testified as follows: "Q. So whether they were talking about narrower spreads or wider spreads, you would have included that in your catalogue of SCI because they were discussing spreads? A. I logged those conversations where they were talking about spreads."

could be imprecise, which could affect the maximum margin of error implicitly targeted by Dr. Singer. In addition, any statistical tests based on such inaccurate and imprecise estimates are also unreliable. The failure to provide a clear and objective set of rules does not comport with well-accepted sampling and measurement practices.[19]

19. Dr. Singer's statistical test to determine whether the alleged exchanges of SCI were "pervasive" is also flawed. Dr. Singer claims that "[t]he hypothesis to be tested, using standard statistical sampling methods, is that the exchange of SCI among Defendants was pervasive, in the sense of occurring on all or almost all trading days during the Class Period."[20] This "sense" is defined in such a way as to provide a potentially distorted view, controverting the second pillar of statistics I enumerated above. Dr. Singer has set up a test that is based on the number of days with *at least one* alleged exchange of SCI,[21] meaning that his test would determine that the exchange of SCI was "pervasive,"[22] even if only two traders from two banks exchanged SCI (as coded by Mr. Poynder) on a single currency, provided that this occurred on a sufficiently large number of sample days.[23] In other words, under Dr. Singer's definition of "pervasiveness" he would find that the alleged sharing of information was pervasive, even if Mr. Poynder had only found 90 instances of alleged exchanges of SCI

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[19] *See*, for example, Thompson, Steven K., *Sampling*, Third Edition (Hoboken, NJ: John Wiley & Sons, Inc.), 2012, p. 1. *See also*, Cochran, William G., *Sampling Techniques*, Third Edition (New York, NY: John Wiley & Sons, Inc.), 1977, pp. 4–8.

[20] Singer Report, Appendix 2, p. 41. Additionally, Dr. Singer claims that "the random sample that Mr. Poynder has reviewed to date allows one to reject the null hypothesis that SCI was exchanged on less than 95 percent of the trading days during the Class Period at the 5.4 percent significance level." Singer Report, ¶ 4. Dr. Singer's results are not statistically significant at the level that is most often used in the social sciences, the 5 percent level. "In practice, statistical analysts typically use levels of 5% and 1%. The 5% level is the most common in social science, and an analyst who speaks of significant results without specifying the threshold probably is using this figure." *See* National Research Council, *Reference Manual on Scientific Evidence,* Third Edition (Washington, D.C., The National Academies Press), 2011, pp. 211–302 at 251–252. "[…] Coffman found an intraday statistically significant price reaction on Day 1 only at a 90% confidence level, which is less than the 95% confidence level both experts require in their regression analyses and which the Court finds is necessary. See Hr'g Tr. at 58:14-18, 59:1, 201:16-202:8 (Coffman agreeing that the Reference Guide on Multiple Regression, published by the Judicial Conference of the United States, requires that the level of statistical significance be 95%)." Memorandum Opinion and Order, *The Erica P. John Fund, Inc., On Behalf of Itself and All Others Similarly Situated v. Halliburton Company and David J. Lesar*, No. 3:02-CV-1152-M (July 25, 2015), p. 32.

[21] Deposition of Hal J. Singer, Ph.D., September 27, 2018 ("Singer Deposition"), pp. 167:5–168:20. He testified: "Mr. Poynder made the call, based on his expertise, that within all the chats that he reviewed in that sample day, there was at least one instance or episode of the sharing of SCI."

[22] Singer Deposition, pp.162:16–163:8. He testified: "I would say that the client asked us to make a determination as to whether the sharing of SCI was pervasive. That was an assignment that was given to us by the client."

[23] Singer Deposition, pp. 192:10–192:19. He testified: "[I]f you define your metric as at least one per day on any currency pair, then I can conclude that it is pervasive."

in total, so long as those 90 instances occurred on 90 of the 91 days in the sample.[24] At the same time, had Mr. Poynder found 100,000 instances of purported SCI, each involving all Defendants, the test Dr. Singer has devised would show that it was not pervasive if it had occurred on, say, 65 out of the 91 days in the sample. Leaving aside the flaws in Mr. Poynder's classification, Dr. Singer's test does not take into account the number of alleged instances of SCI being exchanged, the nature of the alleged SCI exchanged (spread-related or not spread-related), the currencies affected, or the number of Defendants involved. To the extent the trier of fact may be interested in reaching conclusions pertaining to specific characteristics of the sample, Dr. Singer and Mr. Poynder should have incorporated such considerations in their research design. Their failure to have done so precludes them from reaching conclusions outside their own, arbitrary definition of "pervasiveness." Dr. Singer and Mr. Poynder have also failed to explain how this definition of "pervasiveness" comports with Plaintiff's theory of liability and damages in this matter.

20. In his deposition, Dr. Singer acknowledged the weakness of his test. He testified that if hypothetically "there is one instance of SCI sharing on 90 days, 90 of the 91 days, [and] all of those instances of information sharing relate to the Swiss franc/New Zealand dollar currency pair,"[25] he is "open to the possibility [that he may] come to a different conclusion, a more limited conclusion."[26] Therefore, Dr. Singer's test is not proper for determining whether the alleged exchanges of SCI were "pervasive." His own testimony shows that his test could yield a result of "pervasiveness," according to his definition, in a situation in which he admits that the alleged exchanges of SCI might not actually be pervasive. Furthermore, to the extent the trier of fact is interested in the prevalence of the alleged exchanges of SCI pertaining only to spreads or those involving only Credit Suisse, Dr. Singer cannot conclude that these exchanges of SCI were "pervasive," even assuming, for the sake of argument, that Mr. Poynder's classification were appropriate and implemented without error.[27]

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[24] *See* Singer Deposition, pp.191:6–18, 211:24–212:20. Singer testified: "Q. But, and we've touched on this earlier, if I asked you to assume that there was SCI sharing on 90 out of the 91 days, but there was only one instance of SCI sharing on each of the 90 days, you would still conclude, as you do, that the information sharing was pervasive throughout the class period, wouldn't you? A. As I defined it, which is happening on all or almost every day that we sampled. Q. That's a yes? A. Yes." He also testified: "A. So if you want me to assume that the true answer was 40 out of 91 as opposed to 90 out of 91, that would have implications."

[25] Singer Deposition, pp. 191:21–192:4.

[26] Singer Deposition, p. 193:5–10.

[27] Based on his own methodology, Dr. Singer would have to conclude that the alleged exchanges of SCI pertaining only to spreads or involving Credit Suisse occurred on *less*—instead of *more*—than 95 percent of the trading days during the proposed Class Period.

21. Perhaps most fatal to the reliability of their opinions, Dr. Singer and Mr. Poynder also fail to acknowledge or quantify the uncertainty arising from measurement error that permeates their measurement and sampling methodology. This error is fatal to two of the three pillars discussed above; it can lead to an estimate of SCI in the sample that is inaccurate and results in an inaccurate margin of error when the estimate is extrapolated to the full population.

22. Measurement error is a well-known concept in social sciences and statistics. It occurs when a variable of interest is not observed directly, but is instead measured imperfectly. Probably the most notable example of measurement error is the fact that Mr. Poynder himself came to *different* and internally inconsistent conclusions when reviewing the *same* communication transcripts more than once (see **Exhibits 1A** and **1B**). There were also instances in Mr. Poynder's deposition in which he was unable to replicate the results he produced in his report (see **Exhibit 2**). As shown below, this inconsistent classification of duplicate chats happened repeatedly in Mr. Poynder's work.

23. The implications of measurement error for statistical analyses depend on both the analyses to be undertaken and the statistical properties of the measurement errors themselves. As a general matter, measurement error and the related problem of correlated errors lead to loss of precision in estimation and a concomitant loss of statistical power. In addition to affecting precision, measurement error can also cause statistical analyses to be biased and therefore unreliable. In particular, in the context of binary determinations and rate estimation, such as estimation of the percent of trading days involving alleged exchanges of SCI in this case, the presence of measurement error virtually always renders rate estimates biased and unreliable.[28]

24. The magnitude of measurement error can be affected by several factors, many of which I understand to be present in Mr. Poynder's process of identifying alleged exchanges of SCI. Measurement error is expected when the measurement of the variable of interest (in this case, whether a communication contains alleged exchanges of SCI) (i) involves complexity, (ii) is based on an inappropriate process, (iii) involves subjective determinations or judgments, (iv) is based on incorrect or even simply incomplete information, or (v) is retrospective rather than contemporaneous. Measurement error is expected when any of these conditions are present, and the more of these conditions that are present, the greater the

[28] Buonaccorsi, John P., *Measurement Error: Models, Methods, And Applications* (Boca Raton, FL: Chapman & Hall/CRC), 2010, pp. 14–15.

expectation that measurement error might be associated with measuring the variable of interest.

25. I understand that some and possibly all of these factors were present when Mr. Poynder reviewed the traders' communications in this matter. First, the determination of whether traders' communications contain alleged exchanges of SCI is a complex process. As acknowledged by Mr. Poynder, the language used by foreign exchange traders is unique and highly specialized.[29] The review process involves reading lengthy communications transcripts. Attention and care has to be exercised to ensure that relevant instances of alleged exchanges of SCI are captured and classified appropriately. Second, Mr. Poynder's process of classifying alleged SCI is likely subjective and inherently biased, because the review process was designed to ultimately reflect Mr. Poynder's judgment—*which may be incorrect*.[30] The resulting measurement errors are likely to predominate in the same direction and could lead to biased rate estimates. Due to the subjectivity of this process, other reviewers such as Mr. Underwood can come to different conclusions in their review of the communications reviewed by Mr. Poynder.[31] Even more notably, Mr. Poynder himself came to *different and internally inconsistent conclusions when reviewing duplicate communications*, which he also double-counted (see above-mentioned **Exhibits 1A** and **1B**).[32] In other words, Mr. Poynder's review process and measurement methodology is so subjective and subject to error that not even Mr. Poynder seems to be able to replicate his own classification. Third, Mr. Poynder's determinations of whether a communication contains alleged exchanges of SCI is based on incomplete information. While he reviewed communications, he did not consider the context around the communication. For example, during his deposition, when Mr. Poynder was asked to interpret part of a conversation between a Credit Suisse trader and a trader from [redacted] Mr. Poynder testified that he "might speculate" but "[he didn't] know" the meaning behind the traders' conversation.[33] Without an understanding of the context around the conversation Mr. Poynder's judgment of

[29] Poynder Chat Report, ¶¶ 39–48, 53.

[30] *See* Poynder Chat Report, ¶ 53.

[31] Underwood Report, ¶¶ 16–19.

[32] *See* Poynder Production Materials, "2018.5.31 Poynder Daily Chat Summaries and Content.xlsx," "17 MAY 2012 Content" and "15 Jan 2010 Content" tabs for examples of how CITI-FX-CIVIL-00263185 and CITI-FX-CIVIL-00263197 and BARC-FX-CIV-00019697 and CITI-FX-CIVIL-00103484, respectively were coded differently.

[33] Poynder Deposition, pp. 53:22–25.

whether a communication contains alleged exchange of SCI is, therefore, by his own admission, speculative and subject to error.

26. Despite extensive evidence that the communication review process is prone to measurement error, Mr. Poynder and Dr. Singer failed to recognize or account for measurement error when carrying out the sampling and measurement methodology. As I discuss in detail below, in his deposition testimony, Mr. Poynder has confirmed that there were errors of several different types in his classification of certain at-issue communications. Dr. Singer also did not account for measurement error when extrapolating Mr. Poynder's results from the sample to the population. In sum, assuming *arguendo* that sampling and extrapolation are appropriate for informing the trier of fact, Mr. Poynder does not follow well-established practice in failing to provide a clear *ex-ante* definition of SCI that could be replicated by an independent researcher. In addition, neither Dr. Singer nor Mr. Poynder account for or quantify measurement error in their sampling and measurement methodology. Measurement error is prevalent in Mr. Poynder's review of communications, as exemplified most clearly by the fact that Mr. Poynder at times came to *different* conclusions while reviewing duplicates of the *same chats*. These failures render their analysis incomplete, potentially biased, and unreliable; certainly, Mr. Poynder and Dr. Singer's analysis would not pass peer review in light of these errors and shortcomings. Consequently, their findings regarding the prevalence of alleged exchanges of SCI cannot be reliably extrapolated to the population.

27. Even setting aside the aforementioned failures, Dr. Singer's claim of allegedly pervasive exchanges of SCI is unreliable because neither Dr. Singer nor Mr. Poynder have shown that Mr. Poynder's measurements of SCI are independent of one another. Stated differently, Dr. Singer and Mr. Poynder have not provided any evidence showing that Mr. Poynder's determination of SCI-sharing on one trading day does not influence his determination of SCI-sharing on another trading day. In addition, to the extent market conditions are correlated over time and traders' communications tend to reflect market conditions, it is possible for the frequencies of traders' communications to be correlated on consecutive trading days. While Dr. Singer assumes independence across observations in his analyses, he fails to provide any explanation as to why the aforementioned concerns are not relevant in the current matter. A reliable sampling and measurement methodology should either explain why each measurement is independent, or account for the potential correlation.

28. Further, neither Mr. Poynder, nor Dr. Singer, took any steps to ensure that their random sampling of trading days yielded a sample of communications that was representative of the full set of communications that took place within the full population of trading days. Mr. Poynder claims that he was asked to "review a randomly selected, statistically representative sample of communications among FX traders working for Defendant banks during the 'Class Period'."[34] However, Mr. Poynder has failed to provide a basis for his assertion that his set of communications is indeed a random sampling of communications. It is my understanding that Dr. Singer determined that a sample size of 91 days would be appropriate and that someone else at Economists Incorporated was then responsible for creating a random sample of *trading days* in the proposed Class Period,[35] for which counsel provided all then available *communications* to Mr. Poynder. It is well known that a sample drawn at random *ex ante* could be demonstrably non-representative *ex post*. In other words, just because a sample is randomly drawn does not ensure that it is representative of the larger population. Well-accepted practice requires statisticians to conduct representativeness tests or take other steps to ensure the representativeness of the sample. Mr. Poynder and Dr. Singer have failed to conduct any representativeness test or offer any alternative evidence to show the communications Mr. Poynder reviewed are representative of the communications in the population of trading days. If they are not, Mr. Poynder's estimates regarding the relative frequency of alleged exchanges of SCI across Defendant Banks do not apply to the overall population.[36]

29. Importantly, statistical conclusions drawn from the sample only apply to the population from which the sample is selected. It is tautologically true that a sample seeks to represent the population from which it is drawn. A well-designed sample strives for more, which is to represent the correct population. Yet Plaintiffs' Experts sidestepped the issue of clearly identifying what the relevant population is to begin with (and what set of communications should be reviewed, given the population of trading days). For example, at the time of Mr. Poynder's review, Plaintiffs' review database did not contain any documents

[34] Poynder Chat Report, ¶ 1.

[35] Singer Deposition pp. 159:9–162:3. He testified: "Q. Mr. Poynder, in his report, says 'We utilized the process in steps outlined by Economists Incorporated, which I understand are being addressed in a separate expert report by Dr. Hal Singer.' That's you. When he refers to a process and steps outlined by Economists Incorporated, do you understand what he is referring to there? A. I presume he means how we got to the 91 days. […] Q: Who ran the random number generator. A. That I'm not sure."

[36] Poynder Chat Report, ¶¶ 36, 70, 109, 110, 111–114.

from Société Générale, RBC, or Bank of Tokyo Mitsubishi.[37] In comparison, Credit Suisse produced more than six million pages of discovery materials.[38] Such a disparity is evidence of the wrong subpopulation having been used for constructing the set of communications. Mr. Poynder's conclusions regarding the relative frequency of alleged exchange of SCI amongst Defendant Banks would, therefore, be compromised by this non-random pattern of missing documents and thus this analysis is plainly not reliable (leaving aside all the other issues with his classification of communications).

30. In conclusion, Dr. Singer's and Mr. Poynder's sampling and measurement plan and implementation thereof are fundamentally flawed and unreliable. In what follows, I clarify the bases for these opinions.

IV. Description of Plaintiffs' Experts' Sampling, Measurement and Extrapolation Methodology

31. Dr. Singer intends to use sampling to establish "the pervasiveness of the exchange of Sensitive Competitive Information."[39] Specifically, Dr. Singer claims that "[t]he hypothesis to be tested, using standard statistical sampling methods, is that the exchange of SCI among Defendants was pervasive, in the sense of occurring on all or almost all trading days during the Class Period."[40] He claims that for this purpose "a random sample of 91 days is sufficient to establish that SCI sharing occurred on at least 90 to 95 percent of the active trading days during the Class Period."[41] In performing this analysis, Dr. Singer claims in his report to have relied on Mr. Poynder's implementation of the sampling methodology, as well as Mr. Poynder's review of communications and definition of what he considers to be the exchange of SCI.[42]

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[37] The conclusion is based on Appendix 5 of the Poynder Chat Report, which lists the Bates ranges of discovery in Plaintiffs' review database at the time of Mr. Poynder's review. Poynder Chat Report, Appendix 5, ¶ 3. It is also consistent with my understanding from counsel.

[38] Poynder Chat Report, Appendix 5, ¶ 3.

[39] Singer Report, Appendix 2, p. 41.

[40] Singer Report, Appendix 2, p. 41.

[41] Singer Report, Appendix 2, p. 41.

[42] Singer Report, ¶¶ 4, 34–38. Dr. Singer states that he takes "no position on the content of these communications, nor do[es] [he] make any inference as to whether such evidence constitutes evidence of collusion or the existence of an agreement." Singer Report, ¶ 35.

32. Mr. Poynder claims to have "review[ed] a randomly selected, statistically representative sample of communications among FX traders working for Defendant banks during the 'Class Period'."[43] He further claims that he selected a "random sample of 91 trading days from the 1,531 total trading days within the Class Period pursuant to instructions provided by Economists Inc. ('EI')."[44] In addition, he claims that to "select the random sample of 91 trading days, [he] utilised the process and steps outlined by Economists Incorporated ('EI'), which [he] understand[s] are being addressed in a separate expert report by Dr. Hal Singer."[45] More specifically, in his report, Mr. Poynder claims to have created a sample using two subpopulations, one for all end of month trading days and another for all remaining trading days in the proposed Class Period.[46] However, in his deposition, Mr. Poynder stated that Economists Incorporated gave him the sample of days and that he had no input in the process.[47] While Dr. Singer testified in his deposition that he was involved in determining that 91 trading days was a sufficiently large sample size for his purported population of 1,531 trading days, he has also testified that he has no recollection as to who at Economists Incorporated was responsible for actually drawing the sample of 91 days.[48] Mr. Poynder further stated that once Economists Incorporated determined the 91 days, counsel provided him with all available communications at that time that occurred on those 91 days.[49]

33. Mr. Poynder was then asked to "use [his] experience to review a randomly selected, statistically representative sample of communications among FX traders working for

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[43] Poynder Chat Report, ¶ 1.

[44] Poynder Chat Report, ¶ 3.

[45] Poynder Chat Report, ¶¶ 3, 49.

[46] The purported details of Mr. Poynder's approach are provided in Appendix 3 of the Poynder Chat Report.

[47] Poynder Deposition, pp. 106:16–107:5. He testified: "Q. […] Who came up with the process for deciding how to choose those 91 days? A. That was Economist[s], Inc. […] Q. You had no input into the process of selecting those days? A. No."

[48] Singer Deposition, pp. 160:2–162:3, 168:17–20. Dr. Singer testified: "A. […] At that point there was a random number generator that selected the 91 draws within the class period, and I felt like the way that you put it, we were the ones who were telling him which days to sample from and that's not the case. Those days were drawn from a random number generator. Q. So fair to say you told them you need 91 days, the random number generator told them which 91 days? A. That's my understanding of what happened, yes. Q. […] Who ran the random number generator? A. That I'm not sure. Q. Do you know whether it was you? A. Oh, it was not me. I don't like to speculate. It is something I could find out for you at a break if you are really interested. It could have been us, and if it was us, I'm sure it was Kathryn, but I can't -- I just don't have enough insight."

[49] Poynder Deposition pp. 106:16–109:4. He testified: "Q. Who came up with the process for deciding how to choose those 91 days? A. That was Economist[s], Inc…. The plaintiff counsel team then went into the database and performed their searches to select the relevant chats and conversations and emails for those dates, and we were given access to that area. Those chats."

Defendant banks"[50] during the proposed Class Period "to determine whether the communications conveyed sensitive customer, order, or pricing information to competitor banks,"[51] or SCI. Specifically, Mr. Poynder defines SCI as "pricing, order, or customer information that FX traders at other banks could plausibly exploit to their advantage, to their customers' disadvantage, or both—as distinguished from generalised commentary or 'market colour'."[52] In his review of traders' communications, Mr. Poynder has focused on identifying three broad categories of purported SCI: "(1) information concerning spreads; (2) information concerning open orders; and (3) information concerning customer identity."[53] To perform his review, Mr. Poynder had his team review the communications between traders from the Defendant Banks on the selected 91 trading days. Mr. Poynder's team, "working under [his] direction, flagged each communication where FX traders working for Defendants exchanged pricing, order, or customer information, and [he] ultimately reviewed each such communication to determine whether the information exchanged was Sensitive Competitive Information, as [he] defined that term."[54] Mr. Poynder concluded based on his review that "FX traders working for Defendants exchanged Sensitive Competitive Information with other Defendants on 90 of the 91 randomly selected days,"[55] [redacted][56]

34. Dr. Singer claims to have extrapolated Mr. Poynder's results to the purported population of 1,531 trading days. Specifically, Dr. Singer claims to have tested whether the exchange of SCI was pervasive from a statistical perspective.[57] He performed a test by calculating the "probability that Mr. Poynder would have found evidence of the exchange of SCI on 90 out of the 91 days in the random sample" under the "hypothesis that SCI was

[50] Poynder Chat Report, ¶ 1.

[51] Poynder Chat Report, ¶ 2.

[52] Poynder Chat Report, ¶ 2.

[53] Poynder Chat Report, ¶ 56.

[54] Poynder Chat Report, ¶ 54. However, in his deposition Mr. Poynder testified that his team only assisted in identifying those communications that involved more than one Defendant and were "substantive." In Mr. Poynder's Deposition pp. 115:23–118:2, he was asked the following: "So [your team] was not making determinations as to whether a chat did or didn't contain some sensitive competitive information. They were really just looking to see whether there were two defendants and whether there was substantive conversation; is that fair?" to which he answered, "Substantive and potentially containing SCI."

[55] Poynder Chat Report, ¶ 4.

[56] Poynder Chat Report, ¶ 4.

[57] Singer Report, ¶ 36.

exchanged on less than 95 percent of the trading days during the Class Period" using binomial distribution.[58] In addition, Mr. Singer estimated the number of alleged exchanges of SCI pertaining to spreads and all SCI categories "that would have been detected if Mr. Poynder had reviewed the full population of 1,531 trading days," and he provided the purported confidence intervals of the estimates at a 95 percent confidence level.[59]

V. Mr. Poynder Fails to Pre-Specify the Definition of SCI Before His Review of Traders' Communications

35. As an initial matter, Mr. Poynder admittedly came up with his definition of SCI while conducting his review of the at-issue communications. During his deposition, Mr. Poynder stated that the "definition [of SCI] was something [he] came up with through the process of doing the analysis to arrive at a convenient term that would encompass the various kinds of information that [he] was observing there."[60] This is in contrast to the well-established notion that a researcher should pre-specify the research design and establish the "rules of the game" prior to conducting the analysis.[61] In other words, someone tasked with reviewing the at-issue set of communications in this matter to determine which communications may have contained exchanges of SCI would need to define what constitutes SCI *before* starting the review of the set of communications and should not alter the definition of SCI *during* their review of the set of communications. In fact, the definition of SCI should not be informed by the review of the at-issue set of communications.

36. It is well known that "moving the goalposts" during an analysis can introduce bias and render the results meaningless. In cases where a pre-specified setup is not possible, a

[58] Singer Report, ¶ 36, Appendix 2.

[59] Singer Report, ¶¶ 37–38.

[60] Poynder Deposition, p. 134:14–18.

[61] "Another characteristic of the randomized experiment is that it can be described as 'pre-specified' research design. In principle, before the experiment is carried out, the researcher is able to dictate in advance what analyses are to be performed. Indeed, in medical research conducted in the US, prior to conducting a medical experiment, investigators will frequently post a complete description of the experiment in advance at a web site such as clincaltrials.gov. This posting includes how the randomization will be performed, the rules for selecting subjects, the outcomes that will be investigated, and what statistical tests will be performed. Among other things, such pre-announcement prevents the possibility of 'selective reporting'—reporting the results only from those trials that achieve the 'desired' result. The underlying notion motivating such procedure has been described as providing a 'severe test'—a test which 'provides an overwhelmingly good chance of revealing the presence of a specific error, if it exists—but not otherwise' (Mayo, 1996, page 7). This notion conveys the idea that convincing statistical evidence does not rely only on the 'fit' of the data to a particular hypothesis but on the procedure used to arrive at the result. Good procedures are ones that make fewer 'errors.'" DiNardo, John, and David S. Lee, "Program Evaluation and Research Designs," in *Handbook of Labor Economics*, Vol. 4A, Orley Ashenfelter and David Card, eds. (Amsterdam, The Netherlands: Elsevier B.V.), 2011, p. 484.

researcher/statistician should acknowledge that fact before conducting the analysis and make sure that the process accounts for that fact and includes appropriate measures to control for potential biases. Yet Mr. Poynder has not even acknowledged that his failure to pre-specify the definition of SCI could introduce bias. In addition, it is impossible for an independent researcher to assess what biases might have been introduced by Mr. Poynder developing his definition of SCI during his review of the communications. Such failure in itself is likely fatal to the reliability of Mr. Poynder's review methodology.

VI. Plaintiffs' Experts' Sampling and Measurement Plan is Fundamentally Flawed and Unreliable

37. In this section, I discuss four flaws with Plaintiffs' Experts' sampling and measurement methodology that render it unreliable. First, when designing and implementing a sampling and measurement methodology, it is common practice for sampling/measuring experts to tie the sampling and measurement methodology to the purpose for which it is being used, here, to support Plaintiffs' theory of liability or damages. However, Mr. Poynder and Dr. Singer have failed to do so. In particular, Mr. Poynder has failed to provide an objective and replicable definition of what he considers SCI. Second, Dr. Singer has failed to clearly explain why the test he devised, which is based on the number of days on which at least one instance of alleged SCI sharing was identified by Mr. Poynder, is relevant and why it is a sufficiently stringent test to establish that the exchange of SCI was indeed "pervasive." Third, Dr. Singer and Mr. Poynder have failed to clearly lay out each of the sampling and measurement steps and make sure each step they implement can be independently replicated. Finally, neither Mr. Poynder nor Dr. Singer conduct any representativeness test or offer any justification for why their sample is representative of the entire population along important aspects. For each of these reasons, and as further explained below, Plaintiffs' Experts' sampling and measurement methodology is unreliable, and, therefore, their analysis would not pass peer review.

A. Mr. Poynder's Definition of SCI is Conceptually Flawed and Plaintiffs' Experts Failed to Explain How it Fits Plaintiffs' Theory of Liability and Damages in this Matter

38. It is well accepted that a sampling/measuring expert must explain how their methodology actually measures what it is designed to measure.[62] In addition, the reviewers must set forth clear and objective guidelines that allow others to replicate their methodology and results.[63] Mr. Poynder and Dr. Singer have failed in both respects. In addition, they do not explain how their methodology actually fits Plaintiffs' theory of liability and damages in this litigation. Plaintiffs allege that "Defendants conspired with each other to fix prices in the FX market,"[64] more specifically, "to widen FX bid-ask spreads."[65] Plaintiffs argue that Defendants carried out this conspiracy "[b]y agreeing to share [valuable and sensitive] information on a persistent, systemic, and interconnected basis" thus "compound[ing] their informational edge."[66] Mr. Poynder was asked to identify "communications" in which Defendants "conveyed sensitive customer, order, or pricing information to competitor banks."[67] Mr. Poynder purported to do this by determining whether the set of communications provided to him by counsel for the sample of 91 trading days contained alleged exchanges of SCI. In his report, Mr. Poynder has defined SCI as "pricing, order, or customer information that FX traders at other banks could plausibly exploit to their advantage, to their customers' disadvantage, or both."[68] Mr. Poynder's methodology, however, is conceptually flawed and, as mentioned above, he has failed to explain how it fits with Plaintiffs' theory of liability.

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[62] *See*, for example, Cochran, William G., *Sampling Techniques*, Third Edition (New York, NY: John Wiley & Sons, Inc.), 1977, pp. 4–8.

[63] "Reliability and validity are two aspects of accuracy in measurement. In statistics, reliability refers to reproducibility of results. A reliable measuring instrument returns consistent measurements. […] Coding provides another example. In many studies, descriptive information is obtained on the subjects. For statistical purposes, the information usually has to be reduced to numbers. The process of reducing information to numbers is called 'coding,' and the reliability of the process should be evaluated." National Research Council, *Reference Manual on Scientific Evidence,* Third Edition (Washington, D.C., The National Academies Press), 2011, pp. 211–302 at 227. *See also*, Lamal, P.A., "On the Importance of Replication," *Journal of Social Behavior and Personality*, Vol. 5, No. 4, 1990, pp. 31–32.

[64] Complaint, ¶ 6.

[65] Class Certification Memorandum, p. 2.

[66] Class Certification Memorandum, pp. 10–11.

[67] Poynder Chat Report, ¶ 2.

[68] Poynder Chat Report, ¶ 53.

39. First, as discussed below, despite Plaintiffs' allegations of a conspiracy to widen spreads, Mr. Poynder coded communications that discussed the narrowing of spreads as exchanges of SCI. Second, Mr. Poynder failed to consider whether the communications complied with current and historical industry standards or were otherwise appropriate. Third, despite acknowledging that information concerning previously executed orders is not SCI, Mr. Poynder admitted that he counted a Defendant as participating in SCI-sharing even if that Defendant left the chatroom before the information had been shared. Fourth, Mr. Poynder counted as a single instance of SCI information shared among numerous Defendants in a single chatroom, but counted as multiple instances of SCI information that was shared with the exact same Defendants, but in multiple chatrooms. Fifth, Mr. Poynder counted as SCI information shared with non-Defendants, without explaining how such information would give Defendants an informational edge over non-Defendants. Each of these flaws demonstrates that Mr. Poynder has not tied his measurement methodology to Plaintiffs' theory of liability or damages.

40. Before I discuss each of these flaws in more detail, I note that Mr. Underwood raises a number of criticisms with regard to Mr. Poynder's definition of alleged SCI. Specifically, Mr. Underwood notes that: (i) unlike what Mr. Poynder claimed in his report, "the exchange of market information in chat rooms could benefit customers by facilitating efficient risk management by the liquidity providers which may, under certain circumstances, be translated into narrower spreads;"[69] (ii) Mr. Poynder "failed to consider whether communications were appropriate under industry standards such as the *FX Global Code*;"[70] (iii) Mr. Poynder classified communications as containing SCI, while, in fact, they contained discussions of "market color;"[71] (iv) Mr. Poynder failed to show any "concrete instances where the prices offered to customers and ultimately traded on were affected by the alleged collusion;"[72] (v) Mr. Poynder failed to establish that the information allegedly shared in the communication was sufficiently detailed to be incrementally valuable;[73] (vi) Mr. Poynder failed to consider

[69] Underwood Report, ¶ 61.

[70] Underwood Report, ¶ 63. Mr. Poynder testified that: "[t]here was no request or attempt to make a judgment on whether it was in line with the code or was doing anything right or wrong." Poynder Deposition, pp. 218:18–219:19.

[71] Underwood Report, ¶ 70.

[72] Underwood Report, ¶ 63.

[73] Underwood Report, ¶ 71.

alternative hypotheses for the at-issue communications, including the possibility that traders exchanged information for the purpose of risk-management;[74] and (vii) Mr. Poynder failed to account for the presence of non-Defendants in certain chat rooms and certain communications, which is at odds with Plaintiffs' claim that Defendants "restricted access to chat rooms used to facilitate their conspiracy."[75]

41. First, Mr. Poynder's measurement of exchanges of SCI does not seem to fit Plaintiffs' theory of liability or damages because Mr. Poynder admitted that his definition of SCI encompassed instances in which traders discussed narrowing spreads.[76] Notably, Mr. Poynder has failed to explain what relevance such an inclusion has in the context of an alleged conspiracy involving the widening of spreads. [redacted].[77] Mr. Poynder nevertheless classified this as an instance of sharing of spread-related SCI.

42. [redacted][78] Mr. Poynder nevertheless flagged this communication as containing three instances of spread-related SCI. [redacted][79] [redacted]

[74] Underwood Report, Section V.B.

[75] Underwood Report, ¶¶ 90–91.

[76] Poynder Deposition, pp. 138:7–139:16. He testified: "Q. So whether they were talking about narrower spreads or wider spreads, you would have included that in your catalogue of SCI because they were discussing spreads? A. I logged those conversations where they were talking about spreads."

[77] Poynder Deposition, pp. 192:5–197:9. He testified: [redacted]

[78] Poynder Deposition, pp. 197:10–200:24. He testified, [redacted]

[79] Poynder Chat Report, ¶ 53.

43. Second, Mr. Poynder has admitted that the information he counted as SCI may be proper and acceptable under current and historical industry standards. Specifically, Mr. Poynder testified that he has not rendered any judgment regarding the appropriateness of the alleged information sharing by traders in the set of at-issue communications, including whether the alleged sharing of information was allowed under the *FX Global Code* or not:

> "As I said before, the task was to analyze the chance to find -- to identify instances where sensitive competitive information was shared, to then categorize those into the categories that we've discussed and to log and record that. There was no request or attempt to make a judgment on whether it was in line with the code or was doing anything right or wrong."[80]

44. In other words, Mr. Poynder has most likely included in his classification of exchanges of SCI exchanges that are appropriate and allowed under current and historical industry standards. I also note that Mr. Poynder has testified that he did not consider whether Defendants' clients had given their consent prior to the traders sharing their information with third parties.[81] However, he has failed to explain why such a classification of communications is consistent with his own definition of SCI, or how such a classification of communications could be helpful for the trier of fact.

45. Third, Mr. Poynder has stated in his report and confirmed in his deposition that he did not intend to classify "market color" (*e.g.*, information regarding past trades) as SCI, given that such information would not provide an informational edge regarding current and future order flow.[82] However, in addition to several classification mistakes, which I will discuss below, Mr. Poynder also made a conceptual choice that is hard to reconcile with his claim of being conservative in not considering market color.[83] In his deposition, Mr. Poynder was

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[80] Poynder Deposition, pp. 134:19–136:14, 218:8–219:19.

[81] Poynder Deposition, p. 144:4–24. He testified: "Q. Did you – in deciding whether to identify that particular situation as the situation of the sharing of SCI, did you consider whether the client, who was the subject of that communication, had previously consented to the sharing of that information? A. That was not part of the process I followed."

[82] Poynder Chat Report, ¶ 2; Poynder Deposition, pp. 132:11–134:8, 169:15–170:15. He testified: "To give you an illustration of the conservatism that I employed that I think we discussed earlier, for instance, in the terms of orders was the timeframe involved on the order. So, for instance, if an order was talked about in the past tense, then I discounted that as market color, or I counted it market color and did not include it in here."

[83] Poynder Chat Report, ¶¶ 4, 55; Poynder Deposition, pp. 98:21–100:4. He testified: "So in the recording of the sharing of price-contingent orders, I took a highly conservative view on accordingly the effect or potentially the effect of sharing. And to be precise, to tell you what I did, I recorded each order that was being talked about. However, there were many occasions where the bank would say something like there are orders. I have orders between 80 and 90. Now in that instance, I don't know whether -- I know that it's plural, but I don't know if the

asked about a chat in which the Credit Suisse trader who was participating in the chat left *before* the alleged exchanges of SCI actually occurred.[84] When questioned, Mr. Poynder stated that it was still acceptable to classify this alleged SCI exchange as being attributable to Credit Suisse because "the chats are persistent," and Credit Suisse had the ability to go back and look at the communication *after it had occurred*.[85] Such an inclusion is inconsistent with Mr. Poynder's earlier testimony that information about orders that occurred *in the past* would not be counted, as those would constitute market color.[86] This inclusion is also inconsistent with Mr. Underwood's statement that "information about spreads quoted in the past […] is not helpful to quote spreads to customers in fast-moving FX markets."[87]

46. Fourth, Mr. Poynder has testified that in instances where the same information was being shared with two different groups of people (for example because a portion of the chat was forwarded to another party) he would count it multiple times.[88] The following hypothetical illustrates the nonsensical nature of Mr. Poynder's classification procedure. Assume a situation in which all 16 Defendants are in a chat and exchange what Mr. Poynder would classify as one piece of SCI related to spreads. Under his method, he would count a single instance of spread-related SCI and his spreadsheet would show that the 16 Defendants were involved. Assume now, that the same content is discussed by two defendants only, but then forwarded to a third defendant. In this case, Mr. Poynder would count two instances of spread-related SCI, *even though in this hypothetical the same information is shared among three as opposed to 16 Defendants*. Finally, assume that the same information is shared between the same two Defendants initially, but then forwarded individually by one defendant to each of the remaining 14 defendants. In such an instance, Mr. Poynder's method would count 15 instances of spread-related SCI exchange, one for the initial sharing plus one

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number of orders is two or ten or 50. I don't know. And so I wanted to record the fact that it was plural, but being conservative, I recorded it as two."

[84] Poynder Deposition, pp. 126:22–129:3. He testified: "Q. Does this appear to be a situation in which Credit Suisse dropped out of the chat before SCI was shared? A. That appears to be the case, yeah." (Poynder Deposition, Exhibit 7).

[85] Poynder Deposition, p. 127:13–16. He testified: "A. The presence in the chat -- I'll rephrase that. The chats are persistent. So whether you drop in or drop out, you still have the benefit of being able to see the content."

[86] Poynder Deposition, pp. 132:20–133:3. He testified: "So, for instance, if an order was talked about in the past tense, then I discounted that as market color, or I counted it market color and did not include it in here."

[87] Underwood Report, ¶ 77.

[88] Poynder Deposition, p. 165:6–23. He testified: "Q. Yeah. So where it's the same information being shared, but being shared with two different groups of people, you would count it twice? A. Yes."

instance for each of the 14 times the information was forwarded, *even though the same information was shared among the same group of Defendants*, as in the first hypothetical. Mr. Poynder has failed to articulate why such a classification methodology would make sense in this context, or indeed, why it would not be misleading.

47. Finally, Mr. Poynder has classified as exchanges of SCI instances in which certain customers were present in the chat.[89] However, he has failed to provide a justification as to why such information provides an informational advantage to Defendants, *but not their clients, who are also present in the chats*.

48. In conclusion, Mr. Poynder's definition of SCI is unscientific, internally inconsistent, and ad-hoc, as Mr. Poynder has failed to provide clear and objective rules or guidelines that could be used by an independent researcher to replicate his results. In addition, Mr. Poynder has failed to explain how his purported definition of SCI and his implementation of the review of the communications fits with Plaintiffs' theory of liability or damages in the case. Not surprisingly, Mr. Underwood has come to different conclusions after reviewing some of the at-issue communications reviewed by Mr. Poynder. As I discuss in more detail below, these disagreements show that measurement error is present, and, therefore, Dr. Singer's estimates could be biased and his quantification of uncertainty associated with his estimates could be imprecise.

B. The Test Dr. Singer Has Used To Assess Whether the Alleged Exchanges of SCI Are Pervasive Is Ad Hoc and Insufficient

49. Dr. Singer claims to have achieved his goal of determining whether the exchanges of SCI were "pervasive" by testing if the alleged exchanges of SCI "occur[ed] on all or almost all trading days during the Class Period."[90] Yet, he has failed to explain why such a test is sufficient to achieve the aforementioned objective. Dr. Singer considers a day in his sample

[89] Poynder Deposition, pp. 136:15–137:24. Mr. Poynder testified: "Q. Does -- in your view, does the inclusion of non-defendants in the chats reduce the value of the information or reduce the defendants' ability to use the information in an inappropriate way? THE WITNESS: That involves a value of judgment, I think, on the use of the -- or potential use of the sensitive competitive information, and I wasn't making that kind of judgment. As I said, I was logging the instance where it was being shared, and it was being shared."

[90] Singer Report, Appendix 2, p. 41. Dr. Singer has acknowledged in his deposition that the hypothesis he tested was given to him by Plaintiff's counsel. Singer Deposition, pp. 162:16–163:8. He testified: "Q. Appendix 2 says, in the first paragraph, 'The hypothesis to be tested using standard statistical sampling methods is that the exchange of SCI among Defendants was pervasive in the sense of occurring on all or almost all trading days during the Class Period.' Do you see that? A. Yes. Q. Who decided that was the hypothesis to be tested, was that you or someone else? A. No, I would say that the client asked us to make a determination as to whether the sharing of SCI was pervasive. That was an assignment that was given to us by the client."

to contain the alleged exchanges of SCI, as long as there were *two traders* from *any two of the Defendant Banks* allegedly exchanging SCI (as coded by Mr. Poynder) *at least once at any time within the trading day for at least one currency*. In other words, Dr. Singer would draw the same conclusion irrespective of which Defendants were involved in the alleged exchange of SCI, which types of SCI (*e.g.*, spread-related or not spread-related) were allegedly exchanged, which or how many currencies were allegedly discussed, or the frequency or timing of the alleged exchanges of SCI on a given day. In his deposition, Dr. Singer acknowledged the conclusion drawn from his analysis would not change if at least one alleged exchange of SCI was found by Mr. Poynder within a trading day:

> Q: And let's take another hypothetical. If on a particular day Mr. Poynder found 500 instances of SCI sharing and it came to light that he was wrong 499 out of the 500 times, but he was right one time on a particular day, that wouldn't change -- your analysis wouldn't change at all, would it? A. Correct. If the threshold is at least once on that day, it wouldn't change my measure.[91]

50. Dr. Singer seems to have come up with his ad hoc definition of "pervasiveness;" it certainly is not term of art in economics or statistics. Dr. Singer failed to explain how this definition fits with Plaintiffs' theory of liability and damages in this case. In addition, his definition does not comport with the common sense interpretation of the term, as the following hypotheticals illustrate. Consider the following two hypotheticals: (i) assume a scenario in which Mr. Poynder had found only 90 instances of alleged SCI in total, but those instances occurred on 90 out of the 91 days (one on each of those 90 days). Assume further that only two defendants participated in each of these 90 exchanges; (ii) now assume a scenario in which Mr. Poynder had found 100,000 instances of purported SCI, but those instances occurred on only 65 out of the 91 days (no exchanges of alleged SCI on the remaining 26 days). Assume further that all 16 Defendants were involved in these 100,000 exchanges. Based on his own methodology, Dr. Singer would conclude that in the first hypothetical the exchange of SCI was "pervasive," but in the second hypothetical Dr. Singer's test would suggest that the exchange of SCI would not have been "pervasive."[92]

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[91] Singer Deposition, p. 174:11–22.

[92] Following the methodology in Appendix 2 of the Singer Report, if it were true that SCI was exchanged on 95% of the trading days during the Class Period, then the odds that Mr. Poynder would have found evidence of the alleged exchange of SCI on 65 trading days or less would be lower than one out of a million. This probability can be obtained based on a binomial distribution by calculating the cumulative probability for

51. Put simply, Dr. Singer tests a binary variable that indicates whether Mr. Poynder found *at least one* exchange of alleged SCI (for at least one currency involving at least two Defendants), regardless of any other factor. Given that Dr. Singer has set up his test in this way, it is unclear why Mr. Poynder is even trying to generate counts of different types of SCI, beyond the binary variable that indicates whether any incident of SCI allegedly occurred on each date, as Mr. Poynder's counts have no bearing on Dr. Singer's test. Furthermore, Dr. Singer has failed to provide any economic rationale as to why this particular test is sufficiently robust to test his hypothesis. To the extent that certain factors, such as the Defendants involved or frequencies other than a trading day,[93] matter to the trier of fact to assess the pervasiveness of the alleged exchanges of SCI, Dr. Singer's and Mr. Poynder's failure to consider them in their sampling and measurement plan would render the trier of fact unable to conclude whether alleged exchanges of SCI were "pervasive." After all, the only conclusion one would be able to draw using Dr. Singer's methodology is specific to Dr. Singer's own arbitrary and narrowly defined notion of "pervasiveness." Dr. Singer has acknowledged the weakness of his statistical test to some extent in his deposition:

> "Q. Let me give you a different hypothetical. The same situation as we just described, there is one instance of SCI sharing on 90 days, 90 of the 91 days, all of those instances of information sharing relate to the Swiss franc/New Zealand dollar currency pair, hypothetically. Do the conclusions that you reach change? A. The conclusions, just in the section change, or over my entire report? I'm sorry. Q. Just in the section, that there was pervasive information sharing throughout the class period across all currency pairs. A. Well, that's not what this section of the report concludes, right? This section says that if you define your metric as at least one per day on any currency pair, then I can conclude that it is pervasive. I think now you are asking me a hypothetical in which the only types of currency pairs over which you found -- sorry, yeah, the only exchange of SCI pertained to one specific currency pair, and it is only one every day of the sample, would I then be able to infer from that, that based on this exercise, there was a sharing of SCI across all currency pairs? I probably, if that's what the fact pattern really looked like, you know, I

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detecting exchanges of SCI on 65 days or fewer assuming the true probability of alleged exchanges of SCI is 95%. In other words, one would conclude that the true probability of alleged exchanges of SCI in the proposed Class Period is less than 95% at the one percent significance level.

[93] I understand from Mr. Underwood that the nature of the FX market is "fast-moving." Underwood Report, ¶ 77.

> hate to say what I would conclude, but I'm open to the possibility I come to a different conclusion, a more limited conclusion."[94]

52. As a result, Dr. Singer's sweeping conclusion that "the exchange of Sensitive Competitive Information among Defendants, as defined and assessed by Mr. Poynder, was pervasive in a statistical sense" is overly broad and inaccurate.[95] In his report, Dr. Singer claims that "one can reject the null hypothesis that SCI was exchanged on less than 95 percent of the trading days during the Class Period at the 5.4 percent significance level."[96] He reaches this conclusion by using Mr. Poynder's purported findings that there are 90 days with alleged exchanges of SCI out of the 91 sample days. However, if the trier of fact were interested in the prevalence of the alleged exchanges of SCI pertaining only to spreads, Dr. Singer would have found that he could not draw the same conclusion using his methodology, as the alleged exchanges of spread-related SCI took place on 77 rather than 90 out of the 91 sample trading days.[97]

53. [redacted].[98, 99] [redacted].[100]

[94] Singer Deposition, pp. 191:21–193:10.

[95] Singer Report, ¶ 57.

[96] Singer Report, Appendix 2, p. 41. As discussed in footnote 20, Dr. Singer's test does not pass at conventional levels of statistical significance of 5%.

[97] Poynder Chat Report, ¶ 69. Following the methodology in Appendix 2 of the Singer Report as discussed earlier, if it were true that spread-related SCI was exchanged on 95% of the trading days during the Class Period, then the chances Mr. Poynder would have found evidence of the alleged exchange of spread-related SCI on 77 trading days or fewer would be less than one out of one thousand.

[98] As I will discuss in more detail in Section VII below, Dr. Singer and Mr. Poynder's implementation of their flawed sampling and measurement methodology is such that they cannot reliably draw any inference across Defendants. The example in this paragraph is merely for illustrative purposes.

[99] Poynder Chat Report, ¶ 4. Following the methodology in Appendix 2 of the Singer Report as discussed earlier, if it were true that SCI was exchanged on 95% of the trading days during the Class Period, then the chances Mr. Poynder would have found evidence of the alleged exchange of SCI on 72 trading days or fewer would be less than one out of ten thousand.

[100] Singer Report, ¶ 37. [redacted] Poynder Production Materials, "2018.5.31 Poynder Aggregate Summary of Chat Analysis.xlsx."

54. Related to the discussions above, if the trier of fact were interested in the prevalence of alleged spread-related exchanges of SCI involving Credit Suisse, [redacted] Dr. Singer would again have found that he could not draw the same conclusion using his own methodology.[101]

55. In conclusion, Dr. Singer's test is not proper for determining whether communications were "pervasive," as it could yield a significant result even when Dr. Singer, by his own admission might have reached a more limited conclusion under certain scenarios. Furthermore, if the trier of fact were interested in the prevalence of the alleged exchanges of SCI pertaining only to spreads or those involving Credit Suisse, even assuming, for the sake of argument, that Mr. Poynder's classification were appropriate and implemented without error, Dr. Singer would have found that he could not draw the same conclusion using his methodology. Finally, Dr. Singer and Mr. Poynder's sampling and measurement methodology is not informative for assessing a definition of "pervasiveness" other than the one proposed by Dr. Singer. If the trier of fact were interested in a measure of pervasiveness that considered which Defendants were allegedly involved, different time windows, or other factors, the sampling and measurement methodology devised by Dr. Singer and Mr. Poynder would not be informative.

C. Plaintiffs' Experts Fail to Clearly Lay Out and Properly Implement Their Sampling and Measurement Plan

56. In a standard sampling setting, it is well accepted that a sampling expert will follow a process that will: (i) explain the objective of the sampling methodology, (ii) describe the population being sampled, (iii) verify the relevance of the data in the population, (iv) describe the level of precision that is desired in the relevant result, (v) provide a description of how the variables of interest will be measured, (vi) select the sampling unit, and (vii) describe the size of the sample to be selected.[102]

[101] Poynder Production Materials, "2018.5.31 Poynder Daily Chat Summaries and Cotent.xlsx." Following the methodology in Appendix 2 of the Singer report as discussed earlier, if it were true that spread-related SCI was exchanged by Credit Suisse on 95% of the trading days during the Class Period, [redacted]

[102] Cochran, William G., *Sampling Techniques*, Third Edition (New York, NY: John Wiley & Sons, Inc.), 1977, pp. 4–8.

57. To ensure reliable outcomes, it is crucial for Plaintiffs' sampling and measurement experts to clearly lay out each of the sampling and measurement steps and make sure each step they implement can be independently replicated.[103] Mr. Poynder and Dr. Singer have failed to clearly lay out each step of their sampling and measurement plan and ensure that it can be independently replicated. In addition, as discussed below, the process implemented by Mr. Poynder and Dr. Singer fails to incorporate safeguards required to minimize errors in the sampling, measurement, and extrapolation processes. Such unscientific methodology renders their findings potentially biased and unreliable.

58. The very first step of a standard sampling process is to specify the objective of the sampling methodology and make sure the objective can be achieved by the sampling plan (step (i) discussed above). As I discussed in detail in Section VI.A and VI.B, while Dr. Singer claims that "[t]he hypothesis to be tested, using standard statistical sampling methods, is that the exchange of SCI among Defendants was pervasive, in the sense of occurring on all or almost all trading days during the Class Period,"[104] neither Dr. Singer nor Mr. Poynder have explained why their classification of alleged exchange of SCI and/or their test is sufficient to test this hypothesis.

59. As the next step, the sampling expert typically describes the population being sampled after they specify the objective of sampling (step (ii) discussed above). The sampling expert needs to be able to define whether or not an observation is in the population based on a set of objective rules that allow for a clear delineation of what is in and out of the population. The population to be sampled "should coincide with the population about which information is wanted."[105] This is important because the conclusions drawn from the sample apply only to

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[103] "Reliability and validity are two aspects of accuracy in measurement. In statistics, reliability refers to reproducibility of results. A reliable measuring instrument returns consistent measurements. […] Coding provides another example. In many studies, descriptive information is obtained on the subjects. For statistical purposes, the information usually has to be reduced to numbers. The process of reducing information to numbers is called 'coding,' and the reliability of the process should be evaluated." National Research Council, *Reference Manual on Scientific Evidence,* Third Edition (Washington, D.C., The National Academies Press), 2011, pp. 211–302 at 227; *See also* Lamal, P.A., "On the Importance of Replication," *Journal of Social Behavior and Personality*, Vol. 5, No. 4, 1990, pp. 31–35. In the context of litigation, "[s]pecifying every step of the analysis before beginning the sampling protects the expert from assertions by opposing counsel that the sampling was not conducted in an objective, scientific manner." Weil, Roman L., ed., Frank, Peter B., ed., Kreb, Kevin D., ed., and Wagner, Michael J., ed., *Litigation Services Handbook, The Role of the Financial Expert,* Fourth Edition (Hoboken, NJ: John Wiley & Sons, Inc.), 2010, p. 7.

[104] Singer Report, Appendix 2, p. 41.

[105] Cochran, William G., *Sampling Techniques*, Third Edition (New York, NY: John Wiley & Sons, Inc.), 1977, p. 5.

the target population.[106] In other words, because Dr. Singer wants to draw conclusions about information sharing on trading days during the proposed Class Period, Dr. Singer needs to accurately identify and describe the relevant population of trading days. However, in the current matter, there were inconsistencies between the description in the Poynder Chat Report of how the population of trading days during the proposed Class Period was determined and the code that Economists Incorporated apparently used to draw the sample from the population. Mr. Poynder claims that there are 1,531 trading days in the proposed Class Period;[107] however, the sample selection code provided in the Poynder Production Materials, which was presumably used by Economists Incorporated to generate the sample from the population, actually generates a list of 1,490 trading days. I used Mr. Poynder's code to generate a sample that is consistent with his description in his report.[108] As shown in **Exhibit 5**, Mr. Poynder would have obtained a different sample if he had sampled from the population consistent with his own description. This is yet another example of the types of mistakes that permeate Mr. Poynder's analysis.

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[106] Cochran, William G., *Sampling Techniques*, Third Edition (New York, NY: John Wiley & Sons, Inc.), 1977, p. 5.

[107] Poynder Chat Report, ¶ 3. Dr. Singer also claims that there are 1,531 trading days in the proposed Class Period. Singer Report, ¶ 34.

[108] Poynder Production Materials, "Sample_Days.r." I relied on Mr. Poynder's code and the only change I made was to use the New York Stock Exchange ("NYSE") holidays instead of "U.S. settlement" holidays. This is because Mr. Poynder defines trading days as "non-weekends which were not an official holiday in either London or on the New York Stock Exchange" in his report, while his code uses "U.S. settlement" holidays and "U.K. settlement" holidays instead. The rest of the code remains unchanged and the sample is drawn based on the same random seed as in the original code.

The proposed Class Period consists of 1,587 weekdays. Mr. Poynder's code removes 61 "U.S. settlement" holidays and 36 "U.K. settlement" holidays that are not "U.S. settlement" holidays. Because both Veteran's Day and Columbus Day are "U.S. settlement" holidays, but not NYSE trading holidays, this means, at a minimum, Mr. Poynder's (or Economists Incorporated's) population is different from the population of trading days Mr. Poynder claims to have used in his report (and for which he produced supporting code). In addition, if Mr. Poynder intended to exclude all days on which the NYSE was closed then he should have also excluded from the population October 29, 2012 and October 30, 2012, when the NYSE was closed due to Hurricane Sandy. Therefore, if he excluded London and NYSE holidays as he claimed to have done in his report, he would have drawn a different sample of trading days from a different population.

In addition to producing code that uses "U.S. settlement" holidays and "U.K. settlement" holidays, while his report indicates that he uses London and NYSE holidays, Mr. Poynder's code is also internally inconsistent. When Mr. Poynder conducts stratified sampling, he separates month-end dates from non-month-end dates. In selecting the month-end dates, he picks the last trading day for each month from the U.K. trading days rather than from his set of U.K. and U.S. trading days. December 31, 2010 is identified as a U.K. month end in the dataset of U.K. trading days. However, that day is identified as a "U.S. settlement" holiday by Mr. Poynder's own code and should not be included in the month-end dataset. As a result, Mr. Poynder draws his 91 sample days from a population that has one more observation than the population he described. In other words, even though Mr. Poynder's code identifies the size of the population as 1,490, he draws his 91 sample days from an incorrect population with 1,491 observations. Poynder Chat Report, Appendix 3.

60. After defining the population, sampling experts then typically verify the relevance of the data in the population (step (iii) discussed above). Sampling experts want to make sure that no essential data are omitted and no irrelevant data are included.[109] In this context, it requires verifying the data produced in this matter are complete and Mr. Poynder's measurement is relevant to the goal of the sampling design. Yet as I will discuss below, the set of communications reviewed by Mr. Poynder is incomplete to begin with. In addition, as explained in Sections VI.A and VI.B, Mr. Poynder failed to explain how his classification of alleged exchanges of SCI fits with Plaintiffs' theory of liability or damages in this matter.

61. Sampling experts should also describe the level of precision that is associated with statistical estimates (step (iv) discussed above).[110] Any sample is subject to uncertainty both because only part of the population has been measured (*i.e.*, sampling error) and because the variable of interest could be measured imperfectly (*i.e.*, measurement error). Sampling experts can reduce these two sources of uncertainty by "taking larger samples and by using superior instruments of measurement."[111] As I will discuss in more detail below, while Dr. Singer's analyses purportedly accounted for sampling error (*i.e.* the imprecision arising from the fact that different samples from the same population could result in different estimates),[112] neither Dr. Singer nor Mr. Poynder accounted for measurement error (*i.e.* error in measuring instances of SCI-sharing). To obtain an accurate margin of error when extrapolating a measurement from a sample to an entire population, one must account for and quantify both sampling error and measurement error.

62. Another necessary step of the sampling process is to describe how the variables of interest will be measured (step (v) discussed above).[113] There can be a choice of what to measure and how to measure them in the population. For example, Mr. Poynder has chosen to measure whether or not SCI was disclosed in the set of communications provided to him by counsel on the 91 days sampled. As discussed above, Mr. Poynder has failed to specify an objective criterion with regard to what constitutes the exchange of SCI. In addition, as

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[109] Cochran, William G., *Sampling Techniques*, Third Edition (New York, NY: John Wiley & Sons, Inc.), 1977, p. 5.

[110] Cochran, William G., *Sampling Techniques*, Third Edition (New York, NY: John Wiley & Sons, Inc.), 1977, p. 5.

[111] Cochran, William G., *Sampling Techniques*, Third Edition (New York, NY: John Wiley & Sons, Inc.), 1977, pp. 5–6.

[112] *See,* for example, Singer Report, ¶¶ 36–37.

[113] Cochran, William G., *Sampling Techniques*, Third Edition (New York, NY: John Wiley & Sons, Inc.), 1977, p. 6.

discussed further below, Mr. Poynder's measurement of the variables of interest is based on his own subjective judgment and is prone to measurement error, which Mr. Poynder and Dr. Singer failed to account for or quantify. While Mr. Poynder's measurement methodology involves reviewing all communications initially provided to him for each trading day sampled, Mr. Poynder has not described how different Defendants produced the at-issue communications or performed any analysis to confirm that different Defendants produced documents pursuant to the same or at least similar procedures. Mr. Poynder simply states that "[c]ounsel […] performed searches on the database of documents produced by Defendants to narrow the universe of available communications down to those taking place on the randomly sampled days."[114]

63. Before selecting the sample, a sampling expert must divide the population into subsets that are called sampling units (step (vi) discussed above). These sampling units "must cover the whole of the population and they must not overlap, in the sense that every element in the population belongs to one and only one unit."[115] As I have discussed above, Dr. Singer has apparently selected days as the relevant sampling unit. Dr. Singer and Mr. Poynder have failed to explain why trading days are the relevant unit of measurement, as opposed to, for example, higher frequency intervals given the fast-moving nature of the market, such as hours, or indeed, combinations of currency pairs and higher-frequency time intervals, or combinations of Defendants, currency pairs and higher-frequency time intervals.[116] In addition, Mr. Poynder has even failed to explain clearly how he defined a trading day. Communications and chats in particular, can take place over long periods of time and, in his report, Mr. Poynder has failed to provide a clear explanation of how chats that take place over a period exceeding a certain trading "day" are treated. In his deposition, Mr. Poynder claims that he used the local day and time listed in the chat he is reviewing.[117] Mr. Poynder's use of the local date and time implies that he is not using a fixed 24-hour window. For example, the

[114] Poynder Chat Report, ¶ 50.

[115] Cochran, William G., *Sampling Techniques*, Third Edition (New York, NY: John Wiley & Sons, Inc.), 1977, p. 6.

[116] During his deposition, Dr. Singer testified: "I don't remember in the deliberation that an alternative unit of analysis other than days even came up, but I -- you know, this was done through some discussions with Dr. Caves, myself, and the client." Singer Deposition, p. 169:5–10. *See also*, Underwood Report, ¶ 77.

[117] Poynder Deposition, pp. 111:10–112:6. He testified: "Q. Okay. So you would start at 12.01 a.m. on the relevant day and go to 11:59 p.m., roughly, on the relevant day, in the local time zone? A. Yeah, if that was the case, where it was – if it was that extent of a chat. Often it wasn't. Often it was a lesser time."

number of hours between 12:01am in Hawaii and 11:59pm in Los Angeles would be 27 hours. Given the global nature of these communications, the real time window over which communications happened could be much wider.

64. Sampling experts will also describe the size of the sample they select (step (vii) discussed above). The size of the sample is determined based on a sampling expert's desired level of precision.[118] In this case, neither Mr. Poynder nor Dr. Singer specified the desired level of precision. It appears that Dr. Singer determined the sample size based on a maximum margin of error of 10 percentage points, a confidence level of 95%, and an assumed population size of 1,531 trading days. These parameters would result in a sample size of ninety-one trading days if there were no measurement error (because the maximum sampling error for a 91-day sample is 10 percentage points). Assuming that these are indeed the assumptions made by Dr. Singer, his sample size is likely insufficient for achieving the level of desired precision—a 10 percentage point total margin of error—because, as discussed below, the measurement error is likely to be substantial. Consider the following example: If the measurement error is assessed to be even just 5 percentage points, and the desired maximum total margin of error is 10 percentage points, then the sampling error can be, at most, 5 percentage points. To limit the sampling error to 5 percentage points, Dr. Singer would have needed to increase the size of his final sample to over 300 days, or more than three times his actual sample size.[119]

65. In addition to the steps discussed above, before carrying out any analyses, a rigorous statistician would perform standard sanity checks, such as verifying that the sample is complete, contains relevant information, and has no duplicative observations.[120] Neither Dr. Singer nor Mr. Poynder seem to have done so. Had they performed such sanity checks, they could have avoided certain measurement errors. For example, had Mr. Poynder put in place procedures to check his analysis, he could and should have noticed that there are duplicates in the set of communications he reviewed. More specifically, Mr. Poynder failed to adequately control for the fact that at least portions of certain communications were produced multiple times. The existence of duplicate communications should not be surprising, given that

[118] Cochran, William G., *Sampling Techniques*, Third Edition (New York, NY: John Wiley & Sons, Inc.), 1977, p. 7.

[119] Thompson, Steven K., *Sampling*, Third Edition (Hoboken, NJ: John Wiley & Sons, Inc.), 2012, pp. 59–60.

[120] Cochran, William G., *Sampling Techniques*, Third Edition (New York, NY: John Wiley & Sons, Inc.), 1977, p. 5.

multiple Defendants produced communications and Mr. Poynder focused his review on communications involving traders *from more than one* defendant. Such duplication becomes even more likely when the "'broadcast' feature [of certain chat services] enabled users to type one message and send it simultaneously to multiple chat groups," a feature which is acknowledged by Mr. Poynder in his report.[121] To avoid double counting of the communications with exchanges of SCI, Mr. Poynder should have removed duplicative communications (or duplicative portions of communications) from the materials to be reviewed. As I show below, there are numerous examples of Mr. Poynder reviewing identical communications (or portions of a communication) more than once.[122] Importantly, such duplicative observations would result in Dr. Singer overstating the extrapolated total number of alleged exchanges of SCI in the population, for which he provides confidence intervals in his report.[123]

66. In conclusion, Mr. Poynder and Dr. Singer have failed to provide an appropriate sampling and measurement plan and have not implemented the sampling and measurement plan carefully, which further questions the reliability of their work.

D. Plaintiffs' Experts Fail to Show the Sample Is Representative of the Population for All Characteristics

67. In their reports, neither Mr. Poynder nor Dr. Singer conduct any representativeness test or offer any alternative justification for why the sample can fully represent the entire population. The fact that a sample is drawn at random by itself does not ensure that the sample will necessarily be representative in all dimensions of the underlying population from which it was drawn. Further, it is possible that a sample could be representative in one dimension and non-representative in another dimension. As a result, a sample drawn at random *ex ante* might be demonstrably non-representative *ex post*. This is one of the oldest concerns expressed in the statistics literature regarding random sampling.[124]

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[121] Poynder Chat Report, ¶¶ 36–37.

[122] Note that the chat rooms appear to have allowed traders to send the same message to multiple chat rooms at the same time. In other words, there are multiple chat transcripts across chat rooms in which portions are identical, with portions of the chat differing in content from chats including the traders who were only in some, but not all of the relevant chat rooms.

[123] Singer Report, ¶¶ 37–38.

[124] Samples drawn at random *ex ante* are not necessarily representative *ex post*, and non-representative samples can lead to biased extrapolation results. *See*, e.g., Stephan, Frederick F., "Stratification in Representative Sampling," *Journal of Marketing*, Vol. 6, No. 1, 1941, pp. 38–46 at 39–40; Stock, James H., and Mark W.

68. Importantly, while Mr. Poynder received a sample of 91 trading days, he seems to define his sample (and therefore the population) as the communications that took place on the relevant trading days. He states that he was asked to "review a randomly selected, statistically representative *sample of communications* among FX traders working for Defendant banks during the 'Class Period' (*emphasis added*)."[125] While Plaintiffs' Experts purportedly selected a random sample of 91 *trading days*, their method was not designed to draw a random and statistically representative sample of *communications*—Mr. Poynder simply reviewed all *then* available communications on a random set of trading days. Mr. Poynder would only be able to claim that the set of communications was randomly selected, if the set of communications he reviewed also happen to be random and representative of the population.

69. In fact, the sample was not representative of the population along at least one dimension. At the time of Mr. Poynder's review, Plaintiffs' review database did not contain any documents from Société Générale, RBC, or Bank of Tokyo Mitsubishi.[126] In addition, according to the Bates ranges of materials in Plaintiffs' review database, and as illustrated by the following chart, at the time of Mr. Poynder's review, Credit Suisse produced substantially more pages of materials than any other defendant.[127] In fact, Credit Suisse produced over 6 million pages of materials, while 14 of the 16 Defendants produced less than 1 million pages each:[128]

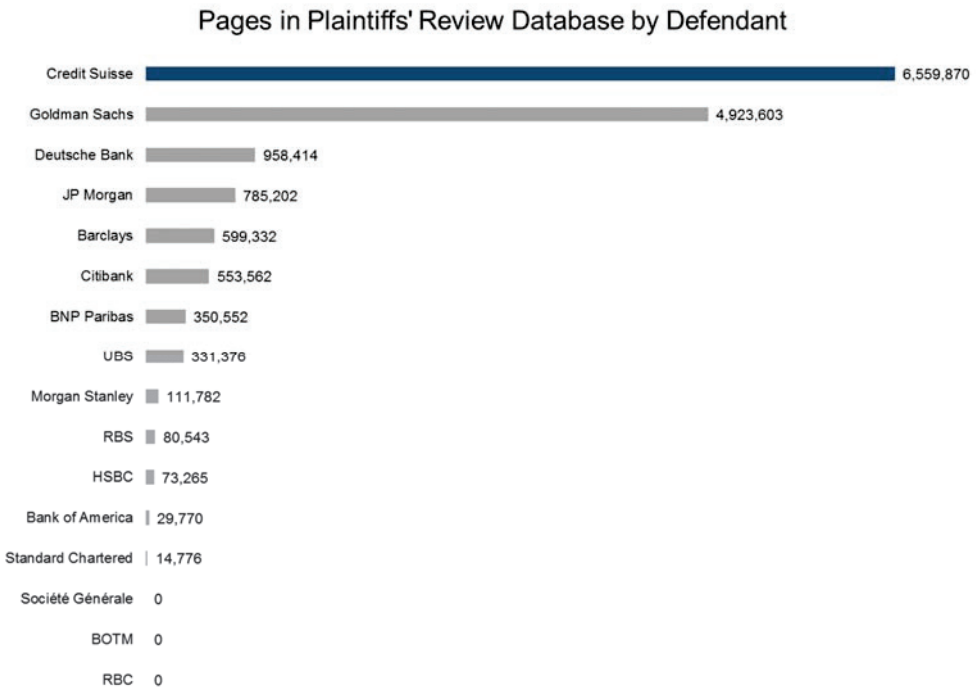
Watson, *Introduction to Econometrics*, Third Edition (Boston, MA: Pearson Education, Inc.), 2015, pp. 475, 483–484.

[125] Poynder Chat Report, ¶ 1.

[126] This conclusion is based on Appendix 5 of the Poynder Chat Report, which lists the Bates ranges of discovery in Plaintiffs' database at the time of Mr. Poynder's review. Poynder Chat Report, Appendix 5, ¶ 3. It is also consistent with my understanding from counsel.

[127] Poynder Chat Report, Appendix 5, ¶ 3.

[128] Société Générale, RBC, and Bank of Tokyo Mitsubishi had not produced any documents at the time of Mr. Poynder's review. Credit Suisse and Goldman Sachs produced over 6 million and 4 million pages of material, respectively. Each of the remaining 11 Defendants produced less than 1 million pages. Poynder Chat Report, Appendix 5, ¶ 3. In addition, Mr. Poynder acknowledged that he received additional production materials after he submitted his report. Specifically, he claims that initially one million communications had been produced and since then an additional 600,000 communications were produced. Poynder Deposition, pp. 10:13–11:20. He testified as follows: "So a process was developed to look at 91 days, which is just under 38,000 chats. At the point when over the 1 million chats was frozen for us to examine. Since then around 600,000 chats have been additionally received." These additional communications are from several defendants, including Barclays and Credit Suisse, but Mr. Poynder was unable to determine which Defendants had produced additional documents, as he had not examined the supplemental materials by the time of his deposition. He testified as follows: "So there are a lot of additional chats from those. I haven't examined them in detail yet, but I took a preliminary look, and the content is generally consistent with what we were seeing before."



70. Because Mr. Poynder appears to have reviewed a set of communications drawn from an incomplete universe of communications, he has no basis to assert that he reviewed "a randomly selected, statistically representative sample of communications among FX traders working for Defendant banks during the 'Class Period'."[129]

71. The issue above highlights one potentially important dimension that Mr. Poynder and Dr. Singer fail to test for representativeness—Defendant Banks. If certain Defendant Banks are overrepresented (or underrepresented) in Mr. Poynder's set of communications, as is clearly the case,[130] then their observed number of alleged exchanges of SCI get excessive (or insufficient) weight in Dr. Singer's extrapolation of number of alleged exchanges of SCI to the entire proposed Class Period. As I discussed above, there are three Defendant Banks for which traders' communications were not available at the time of Mr. Poynder's review. If the characteristics of the set of communications in the sample of trading days are not representative of those in the population as a result of such missing communications, then Mr. Poynder's estimates regarding the relative frequency of alleged exchanges of SCI across

[129] Poynder Chat Report, ¶ 1.

[130] I note that there is no way to tell if the materials that Mr. Poynder received initially by the time of his report was representative in a statistical sense or if there was any bias in the way these documents were produced.

Defendant Banks are unreliable and hence do not apply to the entire set of communications taking place during the population of trading days within the proposed Class Period.[131]

VII. Dr. Singer's Extrapolation Results Are Unreliable Because Mr. Poynder and Dr. Singer Fail to Quantify or Properly Account for Measurement Error

72. Even if one were to ignore all sampling issues associated with Dr. Singer and Mr. Poynder's sampling methodology, their failure to acknowledge or account for measurement error alone renders their analyses unreliable. As discussed below, measurement error is a well-recognized concept in social-science research and is present in Mr. Poynder's review of traders' communications. Notably, Mr. Poynder came to *inconsistent conclusions* when reviewing the *same* chat transcripts more than once. The existence of measurement error compromises the accuracy and precision of any statistical conclusions based on Dr. Singer and Mr. Poynder's sampling and measurement methodology.

A. Measurement Error Is a Well-Recognized Concept in Social-Science Research that Could Impair the Accuracy and Precision of Statistical Estimates

73. Measurement error is a well-known concept in social sciences and statistics. It occurs when a variable of interest is measured imperfectly. Measurement error can be present even in seemingly objective processes. For example, imagine a statistics professor was interested in determining the average length of books in a library. He could ask some of his students to determine (or measure) the length of a sample of books. The students could go to the library, check each sampled book and record the page number on the last page of each book. Even with a relatively objective measure, such as the page number on the last page of a book, measurement error can still occur, for example, if a student were to measure a page other than the last by mistake. When the process is more complex and subjective, it is even more prone to measurement error. For example, imagine a situation in which the statistics professor is interested in measuring how many novels in the English Literature section are "good." The question of whether a book is "good" is of course much more complex and subjective than the question of how many pages a book has, because each student will have to read each book to determine, based on the student's subjective assessment, whether it is "good." One can

[131] Poynder Chat Report, ¶ 109.

easily imagine situations in which different students reading the same book arrive at a different "measurement" of whether the book is "good."

74. As I will explain in more detail below, a properly designed sampling plan needs to take into account and be able to quantify the measurement error inherent in the process. This is because, in the context of binary determinations, the presence of measurement error almost always leads to a biased and less precise (*i.e.*, higher variance) estimate of what the researcher attempts to measure—in this case, whether SCI was purportedly exchanged—than if the measurement error were not present. The bias due to measurement error is substantial in an analysis of communications that involve binary and often subjective determinations.[132] As I will discuss in more detail in Section VII.C, Mr. Poynder in fact came to *inconsistent conclusions* when reviewing *the same* chat transcripts more than once. This highlights the subjective and unreliable nature of Mr. Poynder's review process. Yet, Dr. Singer and Mr. Poynder have failed to recognize or account for measurement error when designing their sampling and communication review methodology. Nor did Dr. Singer account for measurement error when extrapolating Mr. Poynder's purported results from the sample to the population. These failures render both Mr. Poynder and Dr. Singer's conclusions unreliable because measurement error can critically limit what can be learned about a population from a sample.

75. First, measurement error always leads to a less precise estimate of what the statistician attempts to measure;[133] for example, in this case, the percent of trading days involving alleged exchanges of SCI and the total number of alleged exchanges of SCI. Standard sampling uncertainty—such as the sampling error reflected by Dr. Singer's purported confidence intervals and the statistical significance for Dr. Singer's tests[134]—only captures the random variation arising from the fact that only a subset of the population is sampled (*i.e.*

[132] Mr. Poynder implicitly acknowledges that the determination is subjective by admitting that he and his team did not always arrive at the same conclusions regarding the presence of SCI: "The Velador team, working under my direction, flagged each communication where FX traders working for Defendants exchanged pricing, order, or customer information, and I ultimately reviewed each such communication to determine whether the information exchanged was Sensitive Competitive Information, as I have defined that term. […] If I determined that a communication did not exchange Sensitive Competitive Information, then I removed the flag." Poynder Chat Report, ¶¶ 54–55.

[133] Carroll, Raymond J., et al., *Measurement Error in Nonlinear Models: A Modern Perspective*, Second Edition (Boca Raton, FL: Chapman & Hall/CRC), 2006, p. 1.

[134] Singer Report, ¶¶ 36–38. More specifically, Dr. Singer's confidence interval for the number of alleged exchanges of SCI represents the range of values that the true number of exchanges of SCI would purportedly take with 95% probability.

sampling error). It does not account for additional uncertainty due to measurement error. Consequently, Dr. Singer's sampling margins of error are incomplete and systematically *understate* the full extent of error.[135]

76. Second, measurement error may lead statistical analyses to be biased.[136] A statistical analysis is said to be biased if the expected value of its result is different from the actual value of the population parameter being estimated.[137] In other words, bias refers to the tendency of a measurement process to systematically over- and under-estimate the value of the variable of interest, here the questions as to whether specific communications contained alleged exchanges of SCI. Statistical analyses that are known to be unbiased are deemed reliable.[138]

77. In this case, Mr. Poynder applies binary classifications when determining whether each communication and each sampled trading day contains alleged exchanges of SCI; in addition, Mr. Poynder attempts to count the total number of alleged exchanges of SCI in the set of communications. In classifying each communication as containing or not containing SCI, Mr. Poynder can err in two ways. First, Mr. Poynder can determine that a communication contains SCI when, in fact, it does not (*i.e.* a false positive). Second, Mr. Poynder can determine that a communication does not contain SCI when, in fact, it does (*i.e.* a false negative). Unless the ratio of false positives to false negatives matches the odds that a

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[135] In situations where measurements across the units in a sample are interdependent, as is the case here, measurement error will cause the key assumption of statistical independence to be violated and invalidate any margin of error calculations that do not take into account this interdependence. Relatedly, measurement error may lead to a loss of statistical power. Carroll, Raymond J., et al., *Measurement Error in Nonlinear Models: A Modern Perspective*, Second Edition (Boca Raton, FL: Chapman & Hall/CRC), 2006, p. 1. Statistical power refers to the likelihood that a statistical test—in this context, a statistical test based on a variable measured with error—will be able to correctly reject a false null hypothesis. Newbold, Paul, *Statistics for Business and Economics*, Second Edition (Englewood Cliffs, NJ: Prentice Hall), 1988, pp. 377–378. A rejection of a false null hypothesis occurs when the sample has enough information to probabilistically rule out a hypothesis that is in fact incorrect. A major goal of statistical research is to devise statistical tests with good power. A loss of statistical power due to measurement error that was unaccounted for means that the requisite sample size necessary to achieve a given level of statistical power would be larger, potentially substantially larger, than the sample size that would be necessary were measurement error known to be absent. Carroll, Raymond J., et al., *Measurement Error in Nonlinear Models: A Modern Perspective*, Second Edition (Boca Raton, FL: Chapman & Hall/CRC), 2006, pp. 18–19.

[136] Carroll, Raymond J., et al., *Measurement Error in Nonlinear Models: A Modern Perspective*, Second Edition (Boca Raton, FL: Chapman & Hall/CRC), 2006, p. 1.

[137] Thompson, Steven K., *Sampling*, Third Edition (Hoboken, NJ: John Wiley & Sons, Inc.), 2012, p. 99.

[138] While they do not arise in the context of the statistical analyses relevant to this matter, statistical analyses that are known to have a bias that declines as the sample size increases are also sometimes deemed reliable.

communication will in reality contain SCI, measurement error will lead to a biased result.[139] Even a small measurement error in binary determinations could have a substantial impact on the estimate. Regardless of the magnitude of the true rate of days involving alleged exchanges of SCI, measurement error can lead to an observed rate of days involving alleged exchanges of SCI as low as 0% (when the false positive rate is 0% and the false negative rate is 100%) and as high as 100% (when the false positive rate is 100% and the false negative rate is 0%).

78. Hence, ignoring the presence of measurement error would lead a statistician to understate the level of uncertainty in the sample estimates, may result in sample sizes that are inadequate to achieve the desired level of statistical precision or statistical power, and may bias those estimates depending on the statistical properties of the measurement error being ignored.

B. Mr. Poynder's SCI Exchange Review Process Is Subjective and Prone to Measurement Error

79. In general, the severity of the measurement error depends on a number of factors, including whether the measurement: (i) involves complexity;[140] (ii) is based on an inappropriate process, *e.g.*, if the process is biased in some way; (iii) involves subjective determinations or judgment even when based on an appropriate process; (iv) is based on incorrect or simply incomplete information; or (v) is retrospective rather than contemporaneous. In particular, measurement error may increase if it is difficult to re-create the situation in which the initial measurement was made.

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[139] *See*, for example, Carroll, Raymond J., et al., *Measurement Error in Nonlinear Models*: A Modern Perspective, Second Edition (Boca Raton, FL: Chapman & Hall/CRC), 2006, pp. 41–42. *See also*, Buonaccorsi, John P., *Measurement Error: Models, Methods, And Applications*, (Boca Raton, FL: Chapman & Hall/CRC), 2010, pp. 14–15. More generally, it may be possible that measurement error does not compromise the unbiasedness of an estimate outside the context of binary classification. An example of this type of situation is where the discrepancy between the true measure and the observed measure—the measurement error—is distributed symmetrically around zero and is independent of the true measure. For example, if measurement error arises because of the imprecision of a specific device (e.g., a scale) and this measurement error is known to be independent and follow the normal distribution with a mean zero (meaning the scale is as likely to understate the true weight of the object being measured as it is to overstate it, and by the same magnitude, and that the magnitude and the direction of the error does not depend on the true weight), then it might be appropriate to utilize the average of the observed measure as an estimate of the true measure. This is because in such a context, the understatements and overstatements are expected to offset each other and have no bearing on the underlying actual weights.

[140] Fuller, Wayne A., *Measurement Error Models* (Hoboken, NJ: John Wiley & Sons, Inc.), 1987, p. 8.

80. Mr. Poynder's measurement of the alleged exchanges of SCI in the set of trader communications is exposed to each of the five factors described above that typically contribute to an increase in measurement error. I will now address these factors one by one.

81. First, unlike the measurement of the length of books, deciding whether or not a communication contains SCI is a complex process. The "measurement" in this context involves the review of lengthy communications where attention and care has to be exercised to ensure that relevant instances of alleged exchanges of SCI are caught. In addition, the language used by traders is, as recognized by Mr. Poynder,[141] unique and highly specialized. In his deposition, Mr. Poynder acknowledged that when reviewing traders' communications, he might interpret the communication differently from the traders in the chat.[142] Dr. Singer also recognized the subjective nature of Mr. Poynder's review, testifying that "there might be subjective elements to [the definition of SCI]."[143]

82. In fact, there are multiple instances where Mr. Poynder came to inconsistent conclusions when reviewing the same communication transcript more than once, illustrating the complexity of measuring SCI. For example, during his deposition, on four separate occasions Mr. Poynder was unable to replicate his own measurement of SCI. Not only was Mr. Poynder not able to replicate his measurement when asked to recode a communication without being reminded of his prior results, but he was also not able to replicate his results even after he was told what his prior results had been.[144] For instance, Mr. Poynder was told

[141] Poynder Chat Report, ¶¶ 7, 40.

[142] Poynder Deposition, pp. 195:6–196:5. He testified: "Q. […] I just want to know whether you believe that your interpretation is always correct, or whether it might not be in certain instances, because as you have said, you are not the trader uttering these words and they may have something different in mind. So which of those two things is it? […] THE WITNESS: […] What I'm just pointing out to you is these two guys on this day may have had a different interpretation, or they might be talking about a particular kind of client. But 'good guy' means, in some way, a client that is going to be more good. Bad English, but more good than another guy" (Poynder Deposition, Exhibit 18).

[143] Singer Deposition, pp. 195:19–196:10.

[144] Poynder Deposition, pp. 158:3–162:11. He testified: "Q. Let's just start with the SCI. Yeah, if you could just go through unfortunately line-by-line, because I count in your spreadsheet, you've identified 17 instances of either stop loss or take profit, so if you could just point them out in the text here. … Q. We have ten stop losses? A. Yeah. Looks like I missed one. Q. All right. Because in your spreadsheet, you have nine stop losses? A. Right. Q. So you missed one. Okay. Great. Okay" (Poynder Deposition, Exhibit 14). Poynder Deposition, pp. 167:10–170:16. In addition, he testified: "Q. So just based on that, should this count, given that it appears to be a previously executed transaction, should this, in your mind, count as an instance of SCI? A. It's difficult looking at it in isolation like this, but possibly. Q. Sorry. Possibly it should count or possibly it should not count? A. Possibly it should not. Q. It should? A. Possibly it should not. Q. Oh, should not" (Poynder Deposition, Exhibit 17). Poynder Deposition, pp. 212:13–21. He testified further: "Q. I think this is Row 55. It looks like you've got one live order and two fixes. A. Yeah. Q. Maybe you can point out the live order and the two fixes in the text of the chat. A. So reading it here, what I'm actually seeing are three fixes and no order. Q. Sorry. Three fixes and no live order? A. No live order" (Poynder Deposition, Exhibit 22). Poynder Deposition,

during his deposition that he had flagged a communication as containing one instance of spread-related SCI. Nevertheless, when asked to review the communication, Mr. Poynder testified that he could not identify that instance of spread-related SCI.[145] In addition, as I will discuss in detail below, Mr. Poynder himself came to *different* and internally inconsistent conclusions when reviewing the duplicates of the *same* communication transcripts (see **Exhibits 1A** and **1B**).

83. Second, the measurement process described by Mr. Poynder is likely biased. As I will discuss in detail later, because the review process was reportedly designed to ultimately reflect Mr. Poynder's judgment—*which may be incorrect*—the resulting measurement errors are likely to predominate in the direction of the bias and hence be correlated. Because of the biases in the process of Mr. Poynder's review, the false positives and the false negatives generally may not offset each other. Such a presence of measurement error would lead to biased estimates.

84. Third, Mr. Poynder's review is a subjective process, which can amplify measurement error. As discussed above, Mr. Poynder ultimately determines whether and, if so, to what degree, a given communication contains SCI. Subjective decisions such as a determination of whether a communication contains alleged exchanges of SCI can be affected simply by who is reviewing the communication. Social scientists have studied the effect of measurement challenges on individual decision-making and have found that two individuals both possessing the necessary expertise may approach a given problem using different measurement techniques and thus come to opposite conclusions. This may be so even in situations where the measurement involves a seemingly objective determination. It is all the more likely to be so in situations where the measurement involves a subjective determination and judgment.

85. Fourth, Mr. Poynder's current measurement of whether a communication contains SCI is based on incomplete information. Mr. Poynder reviewed selected chat excerpts, but he

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pp. 222:12–223:3. He also testified: "Q. I'm not looking for the live order or stop loss information. Just if you can identify the spread SCI. A. I can't see a spread there. Q. Sorry. You cannot see a spread? A. I can't see a spread" (Poynder Deposition, Exhibit 25).

[145] Poynder Deposition, pp. 222:12–223:3. He testified: "Q. I'm not looking for the live order or stop loss information. Just if you can identify the spread SCI. A. I can't see a spread there" (Poynder Deposition, Exhibit 25).

does not have the entire context surrounding the communications.[146] Indeed, Mr. Poynder admitted that he did not account for the intentions of traders or their customers when reviewing their chat transcripts.[147] After all, Mr. Poynder does not know about the trading relationships between the traders at the time of each chat. Nor does Mr. Poynder, as he admitted in his deposition, know whether the information he classified as SCI has been shared with other market participants.[148] To the extent the information Mr. Poynder classified as SCI has in fact been shared with Defendants' customers, he could no longer draw the conclusion that "[t]he holder of this kind of detailed information has an advantage over other market participants that do not possess this information."[149] However, as I discussed in Section VI, Mr. Poynder admitted in his deposition to have classified as alleged exchanges of SCI instances of communications where non-defendant bank entities are included.[150]

86. Lastly, I understand that Mr. Poynder was asked to determine *today* if a communication up to more than *ten years ago* contained exchanges of SCI. This long gap in time, together with the fundamental distinction between an *ex ante* and an *ex post* perspective, is likely to introduce hindsight bias that, in turn, can introduce or amplify measurement error. Hindsight bias is well known in the social sciences and refers to the

[146] Deposition of John Callaghan, August 6, 2018 ("Callaghan Deposition"), pp. 253:9–256:17. [redacted] Callaghan Deposition, pp. 19:18–22:22. [redacted]

[147] Poynder Deposition, pp. 213:18–214:10. He testified: "So when I was looking through chats, as I said, the intent behind the conversations wasn't measured. I have no opinion on that."

[148] Poynder Deposition, pp. 136:15–137:24. He testified: "Q. […] Did you intend to include in your count of instances of SCI sharing situations like that, even though a non-defendant was in the chat and also receiving the information? A. There may have been non-defendants in some of the chats. I wasn't logging them, so I don't know to what extent – you know, how many there were."

[149] Poynder Chat Report, ¶ 29.

[150] Poynder Deposition, pp. 136:15–137:24. He testified: "Q. […] Did you intend to include in your count of instances of SCI sharing situations like that, even though a non-defendant was in the chat and also receiving the information? A. There may have been non-defendants in some of the chats. I wasn't logging them, so I don't know to what extent – you know, how many there were."

inclination to view an event as predictable *after* it has happened, even though there was no basis to assert its predictability *before* the event happened.[151] The social science literature is rich with evidence of hindsight bias in a variety of contexts.[152] Such hindsight bias has been found to occur across a variety of situations,[153] and could have a substantial impact on measurement error.

87. Hindsight bias may be particularly likely here in the wake of the benchmark rate investigations and litigations in the U.S. and Europe, which led news outlets to frequently discuss traders' communications as problematic. It may be hard for a reviewer to remain unbiased given the prevalence of reports on this issue. This may also make it difficult to assess whether a communication contains alleged exchanges of SCI even when a reviewer seeks to adopt an *ex ante* perspective.

88. Because of the factors discussed above, measurement error is not merely possible, but is likely substantial. Further, as discussed below, there is clear evidence of measurement error in Mr. Poynder's work.

C. Example of Measurement Error in Mr. Poynder's Chat Review

89. As I discussed above, the measurement of alleged exchanges of SCI as designed and implemented by Mr. Poynder is highly subjective and cannot be replicated by an independent

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[151] *See, e.g.,* Gilovich, Thomas, Dale Griffin, and Daniel Kahneman, *Heuristics and Biases: The Psychology of Intuitive Judgment* (New York, NY: Cambridge University Press), 2002, p. 134.

[152] Fischhoff, Baruch, "Hindsight ≠ Foresight: The Effect of Outcome Knowledge on Judgment Under Uncertainty," *Journal of Experimental Psychology: Human Perception and Performance*, Vol. 1, No. 3, 1975, pp. 288–299 at 297; Wood, Gordon, "The Knew-It-All-Along Effect," *Journal of Experimental Psychology: Human Perception and Performance*, Vol. 4, No. 2, 1978, pp. 345–353; Leary, Mark R., "Hindsight Distortion and the 1980 Presidential Election," *Personality and Social Psychology Bulletin*, Vol. 8, No. 2, 1982, pp. 257–263.

[153] *See also*, Fischhoff, Baruch, and Ruth Beyth, "'I Knew It Would Happen': Remembered Probabilities of Once-Future Things," *Organizational Behavior and Human Performance*, Vol. 13, No. 1, 1975, pp. 1–16 at 1; Christensen-Szalanski, Jay J. J., and Cynthia Fobian Willham, "The Hindsight Bias: A Meta-analysis," *Organizational Behavior and Human Decision Processes*, Vol. 48, No. 1, 1991, pp. 147–168; Hawkins, Scott A., and Reid Hastie, "Hindsight: Biased Judgments of Past Events After the Outcomes Are Known," *Psychological Bulletin*, Vol. 107, No. 3, 1990, pp. 311–327; Campbell, Jennifer D., and Abraham Tesser, "Motivational interpretations of hindsight bias: An individual difference analysis," *Journal of Personality*, Vol. 51, No. 4, 1983, pp. 605–620; Fischhoff, Baruch, "Perceived Informativeness of Facts," *Journal of Experimental Psychology: Human Perception and Performance*, Vol. 3, No. 2, 1977, pp. 349–358; Powell, Jack L., "A Test of the Knew-It-All-Along Effect in the 1984 Presidential and Statewide Elections," *Journal of Applied Social Psychology*, Vol. 18, No. 9, 1988, pp. 760–773; Synodinos, Nicolaos E., "Hindsight Distortion: 'I knew-it-all along and I was sure about it,'" *Journal of Applied Social Psychology*, Vol. 16, No. 2, 1986, pp. 107–117; Bryant, Fred B., and Jennifer Howard Brockway, "Hindsight Bias in Reaction to the Verdict in the O. J. Simpson Criminal Trial," *Basic and Applied Social Psychology*, Vol. 19, No. 2, 1997, pp. 225–241.

researcher. As I will discuss further below, Mr. Underwood indeed came to different conclusions than did Mr. Poynder when reviewing certain communications, indicating that measurement error is not merely a theoretical possibility, but a reality in Mr. Poynder's analysis.

90. In fact, the presence of measurement error could not be more evident as Mr. Poynder himself could not replicate his own measurements in certain instances. This is evidenced by the fact that when he was asked during his deposition to review certain traders' chats that he has previously reviewed for his report, he could not arrive at the same classifications of alleged exchanges of SCI as he had previously.[154] **Exhibit 2** shows an example of Mr. Poynder being unable to replicate a measurement of SCI contained in his report during his deposition. In his report, Mr. Poynder identified an instance of spread-related SCI, but he admitted in his deposition that he could not replicate this purported result.[155]

91. In addition, as discussed in Section VI.C and acknowledged by Mr. Poynder in his deposition,[156] Mr. Poynder has in fact reviewed certain chats more than once, because of duplicative chat transcripts in the set of communications he considered. Importantly, his measurements of alleged exchanges of SCI in these duplicative chats were *internally inconsistent*. This underscores the subjective and unreliable nature of Mr. Poynder's measurement. **Exhibits 1A–1B** show two examples of duplicate chat transcripts that were coded inconsistently by Mr. Poynder. **Exhibit 1A** shows an example from the Poynder Report in which Mr. Poynder classified one version of the same chat (CITI-FX-CIVIL-00263185) as containing two instances of "take-profit" SCI, while he classified the duplicate

[154] Poynder Deposition, pp. 119:7–120:6, 158:3–162:11, 212:13–212:21. Mr. Poynder testified after reviewing a document (Poynder Deposition, Exhibit 5) he had previously flagged as containing SCI: "Q. […] Based on the review you've just undertaken, do you see any SCI in this document? A. Immediately, I hadn't seen anything." He also testified as having made a mistake regarding the count of SCI in another example (Poynder Deposition, Exhibit 14) "Q. We have ten stop losses? A. Yeah. Looks like I missed one. Q. All right. Because in your spreadsheet, you have nine stop losses? A. Right." Mr. Poynder also testified after reviewing a document (Poynder Deposition, Exhibit 22) he had previously flagged as containing one live order and two fixes: "Q. Maybe you can point out the live order and the two fixes in the text of the chat. A. So reading it here, what I'm actually seeing are three fixes and no order."

[155] Poynder Deposition pp. 222:12–223:3. Mr. Poynder testified: "Q. Sorry. You cannot see a spread? A. I can't see a spread" (Poynder Deposition, Exhibit 25).

[156] Poynder Deposition pp. 112:7–24, 152:5–15, 154:25–156:9. He testified: "Q. […] So it was not your intention to count the same chat twice? A. Correct." But later, he testified: "Q. […] Does it; therefore, appear that in your spreadsheet, you have double – inadvertently, but have you double counted this chat conversation? We see two examples of it. Two different rows in your spreadsheet, same conversation; right? A. Interesting. Yes" (Poynder Deposition, Exhibits 10 and 11).

of the same chat (CITI-FX-CIVIL-00263197) as containing seven such instances.[157] Importantly, Mr. Poynder counted *both* versions of the same chats towards his total number of alleged exchanges of SCI. These flaws in Mr. Poynder's methodology lead him to overstate the total number of alleged exchanges of SCI. I also note that the currency pairs identified for the two duplicates differ.

92. **Exhibit 1B** is another example of duplicate chat transcripts that were classified inconsistently by Mr. Poynder.[158] I note that Mr. Poynder determined that one copy (BARC-FX-CIV-00019697) contained two instances of "Live Order" information, while he determined that the other copy (CITI-FX-CIVIL-00103484) contained no such instances. He also determined each copy to contain two instances of fix-related SCI. Again, Mr. Poynder counted both versions of the same chat towards his total number of exchanges of SCI, thereby leading him to overestimate the amount of alleged exchanges of SCI. I also note that the currency pairs identified in the two duplicates differ. The facts that Mr. Poynder failed to recognize that he was classifying the *same chats* multiple times and that he *reached different conclusions* shows how subjective and unreliable his purported findings of exchanges of SCI are. In addition, since Mr. Poynder includes the counts for each instance in which he classified the chats as exchanges of SCI, he overstates the total number of purported exchanges of SCI, rendering his total count misleading and unreliable.

93. **Exhibits 6-7** show additional examples of Mr. Poynder double counting purported instances of SCI. **Exhibit 6** is an example of two chats (UBS-ZINC-CIV-000269485 and GS-FX-CIVIL-02388935) containing the same information that was shared by a UBS trader with two different groups of people. Mr. Poynder was counting the *same SCI as two different instances* of exchanges of SCI being shared, thus effectively doubling the total count of alleged exchanges of SCI. Mr. Poynder has acknowledged in his deposition that he was counting both instances.[159] **Exhibit 7** shows another example of Mr. Poynder double counting his purported findings of alleged exchanges of SCI. The underlying chats for this example (HBEU-FXLITIG-00041559 and RBS-IN-RE-FX-LITIG-00027971) are identical. Even so, Mr. Poynder's backup file shows that he extracted different pieces of it, as shown in

[157] CITI-FX-CIVIL-00263185 [CITI-FX-CIVIL-MS_00231758] and CITI-FX-CIVIL-00263197 [CITI-FX-CIVIL-MS_00231770] are identical copies of the same communication.

[158] BARC-FX-CIV-00019697 and CITI-FX-CIVIL-00103484 [CITI-FX-CIVIL-MS_00006374] are identical copies of the same communication.

[159] Poynder Deposition, pp. 163:3–165:23. Mr. Poynder testified: "Q. [...] So where it's the same information being shared, but being shared with two different groups of people, you would count it twice? A. Yes."

Exhibit 7. I note that Mr. Poynder identified two different sets of participating Defendants across the two identical copies of the chat. Mr. Poynder has acknowledged in his deposition that he has double counted:

> Q. Does [RBS-IN-RE-FX-LITIG-00027921] appear to be -- does this chat that appears in [RBS-IN-RE-FX-LITIG-00027921] appear to be the same chat that appeared in [HBEU-FXLITIG-00041559]? A. It does appear to be the same content. Q. And, similarly, do you believe this contains the same SCI that you identified respectively in the other exhibit? A. It's the same chat. ... Q. Okay. Does it; therefore, appear that in your spreadsheet, you have double -- inadvertently, but have you double counted this chat conversation? We see two examples of it. Two different rows in your spreadsheet, same conversation; right? A. Interesting. Yes.[160]

94. Mr. Poynder's review of the at-issue communications contains additional types of measurement error. These errors include classifications that are inconsistent with his own purported methodology. For example, as I discussed in Section VI.A, Mr. Poynder claims in this report that he excluded from alleged exchanges of SCI traders' discussions related to market color (which includes the exchange of information pertaining to previously executed orders). However, Mr. Poynder admitted in his deposition that he has counted certain instances as alleged exchanges of SCI in various circumstances. [redacted]

> Q. […] [redacted][161]

95. In addition, there are instances in which Mr. Poynder seems to have included communications outside the relevant set of 91 trading days. Mr. Poynder has claimed to only

[160] Poynder Deposition, pp. 147:4–152:15.

[161] Poynder Deposition, pp. 132:11–134:8, 169:15–170:15.

use the portion from 12:01am to 11:59pm local time on the sample day if a chat takes place over multiple days.[162] However, **Exhibit 9** shows that the excerpt of the communication Mr. Poynder appears to have relied on in his review[163] of communications on August 26, 2008, actually occurred on August 27, 2008, and, therefore, outside the period Mr. Poynder purported to review.

96. As an additional example of classification errors made by Mr. Poynder, **Exhibit 10** shows a communication in which Mr. Poynder identified nine stop-losses for the chat in his report, but when asked in his deposition he identified ten instances of stop-loss-related SCI.[164]

97. Not all of the classification errors impact Mr. Poynder's purported counts of alleged exchanges of SCI, but they highlight the lack of reliability of his classification. **Exhibit 11** shows that Mr. Poynder has coded [redacted] as currencies discussed in the chat excerpt. At the same time, [redacted] were also discussed in the excerpt contained in Mr. Poynder's backup file, but he did not capture these additional currencies in his classification.[165]

98. Mr. Underwood reviewed a portion of the communications reviewed by Mr. Poynder. For certain communications Mr. Underwood's assessment contradicts Mr. Poynder's findings. Broadly speaking, Mr. Underwood points out several dimensions along which Mr. Poynder's assessment differs from his own. These areas of potential measurement error include: (i) Mr. Poynder's failure to account for whether communications could enhance the efficiency of FX trading, thereby leading to narrower spreads for customers;[166] (ii) Mr. Poynder's classification of communications as containing SCI, while, in fact, they contained discussions of "market color;"[167] (iii) Mr. Poynder's failure to establish that the information allegedly shared in the communication was always incrementally valuable (which is an

[162] Poynder Deposition, pp. 111:10–112:6.

[163] See Mr. Poynder's production file called "2018.5.31 Poynder Daily Chat Summaries and Content.xlsx" in the tab labeled "26 Aug 08 Content."

[164] Poynder Deposition pp. 156:11–162:11. "Q. We have ten stop losses? A. Yeah. Looks like I missed one" (Poynder Deposition, Exhibit 14).

[165] See GS-FX-CIVIL-02190202 in Poynder Production Materials, "2018.5.31 Poynder Daily Chat Summaries and Content.xlsx," tab "02 September 2009 Content."

[166] Underwood Report, ¶¶ 61, 63.

[167] Underwood Report, ¶ 70.

implicit premise of Mr. Poynder's definition of SCI);[168] and (iv) Mr. Poynder's failure to consider alternative hypotheses for the at-issue communications, which include the possibility that traders exchanged information for the purpose of risk-management,[169] or the possibility that communications happened to facilitate interdealer trades.[170] Mr. Underwood's findings highlight that measurement error is likely to be substantial in Mr. Poynder's analysis.

99. In sum, based on my discussion above and my expertise in economics and statistics, I conclude that Mr. Poynder's review of traders' communications involves a myriad of complex and subjective determinations, each of which is subject to measurement error. The degree of measurement error is further compounded and amplified by the inherently biased communication review process, the insufficient information available for communication review, and the retrospective nature of Mr. Poynder's communication review process. As a result, Dr. Singer's estimates of the percentage of days involving alleged exchanges of SCI is inaccurate and imprecise, and his calculated confidence intervals for the number of alleged exchanges of SCI are inaccurate and overly narrow. Such inaccuracy and imprecision leads Dr. Singer and Mr. Poynder to potentially reach incorrect and misleading conclusions about the alleged pervasiveness of exchanges of SCI among Defendants.

D. Mr. Poynder's Chat Review Process Could Have Been Designed to Quantify and Account for Measurement Error

100. Mr. Poynder and Dr. Singer should have planned to account for and quantify the potential measurement error in the communication review process, because it exhibits many of the characteristics described above that indicate the presence of measurement error. There are well-known techniques employed by social scientists that could allow for the quantification of measurement error.[171] For example, as both introductory and advanced

[168] Underwood Report, ¶ 71.

[169] Underwood Report, Section V.B.

[170] Underwood Report, ¶¶ 69, 76.

[171] *See*, for example, Walter, S. D., and L. M. Irwig, "Estimation of Test Error Rates, Disease Prevalence and Relative Risk from Misclassified Data: A Review," *Journal of Clinical Epidemiology*, Vol. 41, No. 9, 1988, pp. 923–937. *See also*, Hausman, J.A., et al., "Misclassification of the dependent variable in a discrete-response setting," *Journal of Econometrics*, Vol. 87, No. 2, 1998, pp. 239–269. *See also*, Buonaccorsi, John P., *Measurement Error: Models, Methods, and Applications* (Boca Raton, FL: Chapman & Hall/CRC), 2010, pp. 27–28. Using the methodology proposed by Walter and Irwig (1988) and Buonaccorsi (2010) would require observing independent determinations by multiple reviewers of whether each communication contained an alleged exchange of SCI (or repeated, independent evaluation from the same reviewer). By contrast, using the

statistics textbooks explain, a proper methodology for assessing the existence and magnitude of measurement error involves taking repeated, independent measurements. The standard deviation of these repeated measurements may allow one to infer the magnitude of, and potential biases introduced by, measurement error.[172] Alternatively, one could estimate measurement error using data from multiple independent and valid sources. A comparative analysis of the findings from each source could be used to make inferences about the prevalence of measurement error.[173] Yet Mr. Poynder entirely disregards such methods of addressing measurement error.

101. In sum, even assuming *arguendo* that Mr. Poynder and Dr. Singer's sampling and extrapolation methodology could be appropriately used to assess the pervasiveness of alleged exchanges of SCI in this matter, their failure to account for and quantify measurement error renders their methodology incomplete and potentially misleading and unreliable.

VIII. Dr. Singer's Statistical Conclusions Are Unreliable Because Plaintiffs' Experts Fail to Provide Any Evidence to Support their Assumption that the Alleged Exchanges of SCI Are Independent

102. Setting aside the issues mentioned above, Dr. Singer's claim of allegedly pervasive exchanges of SCI is unreliable because neither Dr. Singer nor Mr. Poynder provide any evidence supporting their implicit assumption that the alleged exchanges of SCI measured across trading days are independent. As I discussed in Section IV, Dr. Singer claims to have tested statistically whether the alleged exchange of SCI was pervasive and extrapolated the number of alleged exchanges of SCI from the 91 sample trading days to the population of trading days. One critical assumption Dr. Singer relies on in these analyses is that Mr. Poynder's determination of whether or not one trading day contains alleged exchanges of SCI is not related in any way to Mr. Poynder's determination for another trading day. In fact, the very textbook Dr. Singer cites in his report to support his calculation assumes statistical

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methodology proposed by Hausman, et al. (1998) would not require repeated measurements for the same communication. Instead, it would require additional assumptions about factors that affect whether a communication contains an alleged exchange of SCI.

[172] Freedman, David, et al., *Statistics,* Fourth Edition (New York, NY: W.W. Norton and Company, Inc.), 2007, pp. 100–101; Fuller, Wayne A., *Measurement Error Models* (Hoboken, NJ: John Wiley & Sons, Inc.), 1987, pp. 13–14.

[173] *See*, e.g., Chalfin, Aaron, and Justin McCrary, "Are U.S. Cities Underpoliced? Theory and Evidence," *The Review of Economics and Statistics*, Vol. 100, No. 1, 2018, pp. 167–186 at 168.

independence.[174] However, statistical independence may not be assumed in the current matter, which renders Dr. Singer's conclusions unreliable.

103. As discussed in Section VII.B, Mr. Poynder and his staff made a series of subjective determinations in the process of determining whether a communication contained an exchange of SCI. Importantly, these judgment calls were typically made in a manner reflective of Mr. Poynder's ultimate judgment, and thus were generally not made independently. As Mr. Poynder acknowledges in his report, his team "work[ed] under [his] direction … and [Mr. Poynder] ultimately reviewed each … communication to determine whether the information exchanged was Sensitive Competitive Information."[175] Because the process of reviewing the set of communications was reportedly designed to consistently reflect Mr. Poynder's judgment and Mr. Poynder may interpret some FX terms across different communications in a similar way,[176] the resulting determinations could predominate in the same direction as dictated by Mr. Poynder's own judgment, and, hence, are likely to result in correlated measurement errors, which ultimately lead to biased estimates in the binary context.

104. Another reason Mr. Poynder's review of traders' set of communications may not be independent is that traders' communications tend to reflect market conditions, which could be correlated over time. To the extent that market conditions are correlated over consecutive trading days, it is possible for the frequencies of traders' communications to also be correlated on these trading days. For example, if there were larger than usual volatility pertaining to EURUSD in the FX market on June 17, 2008, it is possible for traders to have numerous discussions about the exchange rates and spreads for EURUSD on that day. As long as the market continues to be volatile on June 18, 2008, traders' discussions about the exchange rates and spreads for EURUSD are likely to continue. This could lead to the alleged exchanges of SCI on June 17, 2008 and June 18, 2008 to be correlated, which would ultimately lead a determination of whether or not a trading day contains alleged exchanges of SCI to be correlated with that of the next trading day. In fact, there are several instances where consecutive trading days are selected into Mr. Poynder's sample,[177] which could lead

[174] Clelland, Richard C., et al., *Basic Statistics with Business Applications*, First Edition (New York, NY: John Wiley and Sons, Inc.), 1966, pp. 117–120 at 117.

[175] Poynder Chat Report, ¶ 54.

[176] *See*, for example, Poynder Chat Report, Appendix 2.

[177] *See*, Poynder Chat Report, Appendix 3.

to a lack of independence in Mr. Poynder's determination of days involving alleged exchanges of SCI.

105. As a result of the lack of independence discussed above, Dr. Singer's purported statistical test of the pervasiveness of exchanges of SCI is invalid. Had Dr. Singer properly accounted for correlated determinations, he may have ended up failing to reject the null hypothesis that "SCI was exchanged on less than 95 percent of the trading days."[178] In addition, Dr. Singer's margins of error for the number of exchanges of SCI in the population, as reflected by his confidence intervals, could be systematically understated. That is, they could be too small and give a false sense of precision regarding Dr. Singer's extrapolated findings of exchanges of SCI. Intuitively, when there are correlated judgments, as in this context, the observed number of trading days (or communications) in the sample overstates the actual number of independent pieces of information contained in the sample. Therefore, both Dr. Singer's purported statistical tests and extrapolated number of exchanges of SCI in the population are unreliable.

IX. Conclusions

106. In my opinion, Dr. Singer and Mr. Poynder's sampling and measurement methodology is flawed and not scientifically reliable for following reasons:

1) Mr. Poynder's definition of SCI is conceptually flawed, highly subjective, internally inconsistent, and unscientific. As an initial matter, Mr. Poynder has failed to pre-specify his definition of what constitutes alleged SCI. His developing of the definition of SCI during his review of the communications can bias his results and render them unreliable. Mr. Poynder has also failed to provide a clear guideline for how he determined whether a communication contains alleged exchanges of SCI and he has failed to explain how his classification of SCI allegedly contained in the at-issue communications fits with Plaintiffs' theory of liability or damages in this matter.
2) Dr. Singer's test is insufficient to assess the pervasiveness of the alleged exchanges of SCI. Dr. Singer's test would determine the exchange of alleged SCI is "pervasive" even if only two traders from two banks exchanged SCI (as coded by Mr. Poynder) on a single currency on a sufficiently large number of sample days. Dr. Singer's test is not proper as it could yield a significant result even if Dr. Singer, by his own admission, might have reached a more limited conclusion. In addition, if the trier of

[178] Singer Report, ¶ 36.

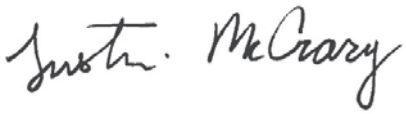
fact were interested in the prevalence of the alleged exchanges of SCI pertaining only to spreads or those involving Credit Suisse, Dr. Singer would have found that he could not reject the same null hypothesis using his own methodology even assuming *arguendo* Mr. Poynder's classification were appropriate and implemented without error.

3) Dr. Singer and Mr. Poynder have failed to clearly lay out and properly implement their sampling and measurement plan. Their implementation is fraught with mistakes.
4) Neither Mr. Poynder nor Dr. Singer have conducted any representativeness test or offered any justification for why their sample of trading days can fully represent the population. In addition, because Plaintiffs' Experts' sampling was conducted based on trading days rather than communications, there is no basis for Mr. Poynder to claim that the communications he reviewed are "randomly selected" and "statistically representative."
5) Mr. Poynder and Dr. Singer have failed to quantify or properly account for measurement error. Measurement error is virtually guaranteed to be present to a substantial degree in Mr. Poynder's review of traders' communications and its existence would compromise the accuracy and precision of any statistical conclusions based on Dr. Singer and Mr. Poynder's sampling and measurement methodology. In fact, Mr. Poynder himself came to *different* and internally inconsistent conclusions when reviewing the *same* communication transcripts more than once.
6) Mr. Poynder and Dr. Singer fail to provide any evidence as to why Mr. Poynder's determination of whether or not one trading day contains alleged exchanges of SCI is statistically independent from that of another trading day, which renders Dr. Singer's statistical conclusions unreliable.

107. Therefore, Dr. Singer and Mr. Poynder's analyses cannot be used to reliably support their purported conclusions.

The opinions expressed in this expert report are based on personal knowledge and review of relevant data and documents. If called as an expert witness, I could and would testify competently thereto. I hereby declare under penalty of perjury that, to the best of my knowledge, each of my opinions and the basis thereof, as contained in this report, are true and correct.

Executed this 25th day of October, 2018



Prof. Justin McCrary

Example of Measurement Error: Mr. Poynder Classifies Two Identical Source Documents and Provides a Different Classification Across the Duplicates

Sample Date	Bates Number	Chat Transcript [1]
5/17/2012	CITI-FX-CIVIL-00263185	[redacted]

Example of Measurement Error: Mr. Poynder Classifies Two Identical Source Documents and Provides a Different Classification Across the Duplicates

Sample Date	Bates Number	Chat Transcript [1]
5/17/2012	CITI-FX-CIVIL-00263197	[redacted]

Example of Measurement Error: Mr. Poynder Classifies Two Identical Source Documents and Provides a Different Classification Across the Duplicates

Sample Date	Bates No	Live Order	Spread	Stop-Loss	Take-Profit [2]	Fix	Customer ID	Currency Pair [2]	Participating Defendants
5/17/2012	CITI-FX-CIVIL-00263185	0	0	2	2	0	0	[redacted]	JPM, CITI
5/17/2012	CITI-FX-CIVIL-00263197	0	0	2	7	0	0	[redacted]	JPM, CITI
Total count of SCI in Mr. Poynder's analysis:				4	9				

Source: 2018.5.31 Poynder Daily Chat Summaries and Content.xlsx, "17 MAY 2012 Content"

Note:
[1] While the excerpts produced by Mr. Poynder in 2018.5.31 Poynder Daily Chat Summaries and Content.xlsx differ, the two underlying PDF source documents, CITI-FX-CIVIL-00263185 and CITI-FX-CIVIL-00263197, are identical. Mr. Poynder includes the classifications for both chat transcripts in his analysis, in spite of the fact that they are duplicates.
[2] Despite classifying the same document twice, with the only difference being the Bates number, Mr. Poynder classifies different currency pairs and different quantities of take-profit SCI between these two chats.

Exhibit 1B

Example of Measurement Error: Mr. Poynder Classifies Two Identical Source Documents and Provides a Different Classification Across the Duplicates

Sample Date	Bates Number	Chat Transcript [1]
1/15/2010	BARC-FX-CIV-00019697	[redacted]

Example of Measurement Error: Mr. Poynder Classifies Two Identical Source Documents and Provides a Different Classification Across the Duplicates

Sample Date	Bates Number	Chat Transcript [1]
1/15/2010	CITI-FX-CIVIL-00103484	[redacted]

Sample Date	Bates No	Live Order [2]	Spread	Stop-Loss	Take-Profit	Fix	Customer ID	Currency Pair [2]	Participating Defendants
1/15/2010	BARC-FX-CIV-00019697	2	0	0	0	2	0	[redacted]	CITI, BARC
1/15/2010	CITI-FX-CIVIL-00103484	0	0	0	0	2	0	[redacted]	BARC, CITI
Total count of SCI in Mr. Poynder's analysis:		2				4			

Source: 2018.5.31 Poynder Daily Chat Summaries and Content.xlsx, "15 Jan 2010 Content"

Note:
[1] While the excerpts produced by Mr. Poynder in 2018.5.31 Poynder Daily Chat Summaries and Content.xlsx differ, the two underlying PDF source documents, BARC-FX-CIV-00019697 and CITI-FX-CIVIL-00103484, are identical. Mr. Poynder includes the classifications for both chat transcripts in his analysis, in spite of the fact that they are duplicates.
[2] Despite classifying the same document twice, with the only difference being the Bates number, Mr. Poynder classifies alleged exchanges of live order SCI and currency pairs differently between these two chats.

Example of Measurement Error: Mr. Poynder Flags Sharing of Information for Trading as Alleged Exchanges of SCI

Sample Date	Bates No	Chat Transcript
7/11/2011	GS-FX-CIVIL-02663202	[redacted]

Sample Date	Bates No	Live Order	Spread	Stop-Loss	Take-Profit	Fix	Customer ID	Currency Pair	Participating Defendants
7/11/2011	GS-FX-CIVIL-02663202	1	1	6	0	0	0	[redacted]	GS, CS

Testimony from Mr. Poynder's Deposition: "Q. So if you look in your spreadsheet, your summary spreadsheet in Row 388, you'll see that you identify one instance of spread, which I assume means the sharing of SCI relating to spreads; do you see that? A. Live order spreads and stop losses. Q. Yeah. You've got one live order, one spread, six stop losses. I don't want to ask you to code the whole chat, but I'm wondering if you're able to look through the chat and identify for me the one instance of spread SCI. [...] A. *I can't see a spread there* ."

Source: 2018.5.31 Poynder Daily Chat Summaries and Content.xlsx, "11 July 2011 Content"; Poynder Deposition pp. 219:21–223:3

Source: 2018.5.31 Poynder Daily Chat Summaries and Content.xlsx, "02 Jul 09 Content"; Poynder Deposition pp. 138:7–139:16; pp. 191:25–197:9

Source: 2018.5.31 Poynder Daily Chat Summaries and Content.xlsx, "8 Jul 2013 Content"; Poynder Deposition pp. 197:10–200:24

Exhibit 5

Sample Days Given from Mr. Poynder's R Code using Mr. Poynder's Inputs v. Correcting for Actual NYSE Holidays and Closures

Mr. Poynder's Inputs			Correcting for Actual NYSE Holidays and Closures		
12/4/2007	10/7/2010	7/5/2013	12/4/2007	9/23/2010	3/13/2013
12/5/2007	10/8/2010	7/8/2013	12/5/2007	10/8/2010	4/4/2013
12/19/2007	11/29/2010	7/15/2013	12/19/2007	10/13/2010	4/5/2013
3/31/2008	12/30/2010	8/6/2013	4/25/2008	12/3/2010	6/5/2013
4/24/2008	12/31/2010	8/9/2013	5/23/2008	12/29/2010	7/17/2013
5/22/2008	3/15/2011	8/20/2013	6/12/2008	1/31/2011	8/12/2013
6/10/2008	4/4/2011	10/24/2013	6/19/2008	3/15/2011	9/4/2013
6/17/2008	4/12/2011	10/31/2013	7/10/2008	3/16/2011	9/11/2013
6/18/2008	4/20/2011	12/4/2013	8/27/2008	4/6/2011	11/7/2013
7/9/2008	5/6/2011		9/16/2008	4/26/2011	
8/26/2008	6/21/2011		11/4/2008	6/2/2011	
9/12/2008	7/11/2011		11/5/2008	6/17/2011	
11/3/2008	8/25/2011		11/24/2008	6/23/2011	
11/4/2008	10/11/2011		11/26/2008	7/14/2011	
11/26/2008	10/24/2011		12/10/2008	9/2/2011	
12/10/2008	11/7/2011		1/8/2009	10/28/2011	
1/2/2009	12/1/2011		1/23/2009	11/11/2011	
1/7/2009	12/6/2011		2/20/2009	12/7/2011	
1/23/2009	12/15/2011		2/26/2009	12/12/2011	
4/16/2009	2/8/2012		4/17/2009	1/23/2012	
5/14/2009	3/9/2012		4/20/2009	1/31/2012	
6/25/2009	3/20/2012		5/18/2009	2/8/2012	
7/2/2009	3/23/2012		6/29/2009	3/26/2012	
7/30/2009	4/4/2012		7/8/2009	3/27/2012	
8/14/2009	4/12/2012		8/5/2009	4/10/2012	
9/2/2009	5/10/2012		8/18/2009	4/16/2012	
10/19/2009	5/17/2012		9/8/2009	4/26/2012	
11/4/2009	7/6/2012		9/30/2009	6/6/2012	
11/19/2009	7/20/2012		10/20/2009	7/20/2012	
12/10/2009	7/31/2012		10/21/2009	7/27/2012	
1/4/2010	8/24/2012		12/10/2009	8/16/2012	
1/15/2010	11/27/2012		1/4/2010	11/5/2012	
1/28/2010	11/29/2012		1/15/2010	12/6/2012	
2/8/2010	12/6/2012		2/1/2010	12/10/2012	
2/11/2010	1/17/2013		2/9/2010	12/12/2012	
2/25/2010	1/29/2013		2/12/2010	12/27/2012	
5/4/2010	1/30/2013		3/1/2010	12/31/2012	
6/23/2010	2/6/2013		5/6/2010	1/18/2013	
7/21/2010	4/9/2013		6/17/2010	2/4/2013	
8/10/2010	4/22/2013		7/15/2010	2/11/2013	
9/20/2010	4/24/2013		7/26/2010	3/12/2013	

Source: Poynder's Production, "Sample_Days.r"

Example of Measurement Error: Mr. Poynder Double Counts Alleged Exchanges of SCI With Two Different Source Documents Involving Different Groups

Sample Date	Bates Number	Chat Transcript [1]
5/17/2012	UBS-ZINC-CIV-000269485	[redacted]

Sample Date	Bates Number	Chat Transcript [1]
5/17/2012	GS-FX-CIVIL-02388935	[redacted]

Example of Measurement Error: Mr. Poynder Double Counts Alleged Exchanges of SCI With Two Different Source Documents Involving Different Groups

Sample Date	Bates Number	Chat Transcript [1]
5/17/2012	GS-FX-CIVIL-02388935	[redacted]

Sample Date	Bates No	Live Order	Spread	Stop-Loss	Take-Profit [2]	Fix	Customer ID	Currency Pair	Participating Defendants
5/17/2012	UBS-ZINC-CIV-000269485	0	0	9	8	0		[redacted]	UBS, JPM
5/17/2012	GS-FX-CIVIL-02388935	0	0	9	7	0		[redacted]	BARC, HSBC, BofA, UBS, CITI, GS, SC
Total count of SCI in Mr. Poynder's analysis:				18	15				

Testimony from Mr. Poynder's Deposition: "Q. [...] So where it's the same information being shared, but being shared with two different groups of people, you would count it twice? A .*Yes* ."

Source: 2018.5.31 Poynder Daily Chat Summaries and Content.xlsx, "17 MAY 2012 Content"; Poynder Deposition 163:3–165:23

Note:
[1] Mr. Poynder includes classifications for both chat transcripts in his analysis, in spite of the fact that they contain the same alleged exchange of SCI.
[2] Despite the two chats including the same alleged exchange of SCI, Mr. Poynder classifies different quantities of take-profit SCI between these two chats.

Example of Measurement Error: Mr. Poynder Misclassifies Participating Defendants in a Duplicate Chat Transcript and Double Counts the Alleged Exchange of SCI

Sample Date	Bates Number	Chat Transcript [1]
5/17/2012	HBEU-FXLITIG-00041559	[redacted]

Sample Date	Bates Number	Chat Transcript [1]
5/17/2012	RBS-IN-RE-FX-LITIG-00027971	[redacted]

Sample Date	Bates No	Live Order	Spread	Stop-Loss	Take-Profit	Fix	Customer ID	Currency Pair	Participating Defendants [2]
5/17/2012	HBEU-FXLITIG-00041559	0	1	0	0	0	0	[redacted]	HSBC, UBS, RBS
5/17/2012	RBS-IN-RE-FX-LITIG-00027971	0	1	0	0	0		[redacted]	UBS, HSBC

Total count of SCI in Mr. Poynder's analysis:	2

Testimony from Mr. Poynder's Deposition: "Q. Does [RBS-IN-RE-FX-LITIG-00027921] appear to be -- does this chat that appears in [RBS-IN-RE-FX-LITIG-00027921] appear to be the same chat that appeared in [HBEU-FXLITIG-00041559]? A. It does appear to be the same content. Q. And, similarly, do you believe this contains the same SCI that you identified respectively in the other exhibit? A. It's the same chat. ... Q. Okay. *Does it; therefore, appear that in your spreadsheet, you have double -- inadvertently, but have you double counted this chat conversation? We see two examples of it. Two different rows in your spreadsheet, same conversation; right? A. Interesting. Yes."*

Source: 2018.5.31 Poynder Daily Chat Summaries and Content.xlsx, "17 MAY 2012 Content"; Poynder Deposition pp. 147:4–152:15

Note:
[1] While the excerpts produced by Mr. Poynder in 2018.5.31 Poynder Daily Chat Summaries and Content.xlsx differ, the two underlying PDF source documents, HBEU-FXLITIG-00041559 and RBS-IN-RE-FX-LITIG-00027971, are identical. Mr. Poynder includes the classifications for both chat transcripts in his analysis, in spite of the fact that they are duplicates.
[2] Despite classifying the same document twice, with the only difference being the Bates number, Mr. Poynder classifies different participating defendants between the two chats, with RBS participating in one chat but not the other.

Exhibit 8

Source: 2018.5.31 Poynder Daily Chat Summaries and Content.xlsx, "17 MAY 2012 Content"; Poynder Deposition pp. 165:24–170:16

Example of Measurement Error: Mr. Poynder Reviews a Chat Transcript from a Date Other than the Sample Date

Sample Date [1]	Bates No	Chat Transcript [1]
8/26/2008	GS-FX-CIVIL-02215707	[redacted]

Sample Date [1]	Bates No	Live Order	Spread	Stop-Loss	Take-Profit	Fix	Customer ID	Currency Pair	Participating Defendants
8/26/2008	GS-FX-CIVIL-02215707	0	0	0	0	1	0	[redacted]	CITI, GS

Source: 2018.5.31 Poynder Daily Chat Summaries and Content.xlsx, "26 Aug 08 Content"

Note:
[1] The "Sample Date" shows August 26, 2008 whereas the Chat Transcript produced by Mr. Poynder shows the first entry beginning on August 27, 2008.

Example of Measurement Error: Mr. Poynder Miscodes a Chat Transcript

Sample Date	Bates Number	Chat Transcript
5/17/2012	UBS-ZINC-CIV-000269485	[redacted]

Sample Date	Bates No	Live Order	Spread	Stop-Loss	Take-Profit	Fix	Customer ID	Currency Pair	Participating Defendants
5/17/2012	UBS-ZINC-CIV-000269485	0	0	9	8	0		[redacted]	UBS, JPM

Testimony from Mr. Poynder's Deposition: "Q. […] [redacted]

Source: 2018.5.31 Poynder Daily Chat Summaries and Content.xlsx, "17 MAY 2012 Content"; Poynder Deposition pp. 156:11–162:11

Example of Measurement Error: Mr. Poynder Reviews a Chat Transcript and Miscodes Currency Pairs

Sample Date	Bates Number	Chat Transcript
9/2/2009	GS-FX-CIVIL-02190202	[redacted]

Example of Measurement Error: Mr. Poynder Reviews a Chat Transcript and Miscodes Currency Pairs

Sample Date	Bates No	Live Order	Spread	Stop-Loss	Take-Profit	Fix	Customer ID	Currency Pair [1]	Participating Defendants
9/2/2009	GS-FX-CIVIL-02190202	0	2	0	0	0	0	[redacted]	CS / BofA / GS

Source: 2018.5.31 Poynder Daily Chat Summaries and Content.xlsx, "02 September 2009 Content"

Note:
[1] Mr. Poynder classifies the following chat as containing [redacted] However, the chat discusses the following currency pairs that Mr. Poynder does not include in his classification: [redacted]

 Appendix A

Justin McCrary

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Current Appointments

Columbia University
2018– Paul J. Evanson Professor of Law

University of California, Berkeley
2010– Professor of Law
2008–10 Assistant Professor of Law

National Bureau of Economic Research
2012– Faculty Research Associate
2006–12 Faculty Research Fellow

Past Appointments

Columbia University
Fall 2017 Samuel Rubin Visiting Professor of Law

University of California, Berkeley
2014–17 Director, Social Sciences Data Laboratory (D-Lab)

University of Michigan
2003–07 Assistant Professor, Gerald R. Ford School of Public Policy
2003–07 Assistant Professor, Department of Economics (courtesy)

European Central Bank (Banco de España)
2013–14 Economist

Federal Reserve Bank of New York
1996–98 Assistant Economist

Education

Ph.D. Economics, University of California, Berkeley, 2003

A.B. Public Policy, Princeton University, 1996

Testimony Experience

Financial Guaranty Insurance Company v. Morgan Stanley ABS Capital I Inc. and Morgan Stanley Mortgage Capital Holdings LLC
Supreme Court of the State of New York, County of New York

- Mortgage-backed securities case
- Testimony regarding sampling and statistical methods
- Retained by Morgan Stanley
- Report filed on October 19, 2018

Shamrell v. Apple Inc.
Superior Court of the State of California, County of San Diego

- Putative class action regarding products liability, Unfair Competition Law and Consumers Legal Remedies Act
- Testimony regarding heterogeneity across putative class members, failure rate methodologies, econometrics, and data science
- Retained by Apple, Inc.
- Supplemental class certifiction report filed on October 17, 2018
- Class certification report filed on March 29, 2017
- Rebuttal report filed on February 1, 2017

Samsung Electronics Co., Ltd., v. Kuroda Electric Co., Ltd.
International Chamber of Commerce

- Contractual dispute
- Testimony regarding economic theory, data science, statistics
- Retained by Samsung Electronics Co.
- Report filed on September 28, 2018

Residential Funding Company v. Universal American Mortgage Co.
United States District Court for the District of Minnesota

- Mortgage-backed securities case
- Testimony regarding sampling and statistical methods
- Retained by Universal American Mortgage Co.
- Report filed on August 30, 2018

In re Gateway Plaza Residents Litigation
Supreme Court of the State of New York, County of New York

- Putative class action regarding warranty of habitability
- Testimony regarding electricity usage, individual preferences and choices, and heterogeneity across putative class members; large scale data analysis
- Retained by Gateway Plaza
- Supplemental class certification and rebuttal report filed on August 8, 2018
- Class certification report filed on September 18, 2017

Financial Guaranty Insurance Company v. Morgan Stanley
Supreme Court of the State of New York, County of New York

Mortgage-backed securities case

Testimony regarding sampling and statistical methods

Retained by Morgan Stanley

Report filed on August 7, 2018

United States of America v. SavaSeniorCare
U.S. District Court for the Middle District of Tennessee

False Claims Act case

Testimony regarding sampling and statistical methods

Retained by SavaSeniorCare

Rebuttal report filed on August 6, 2018

Latoya Brown et al. v. Madison County, Mississippi
U.S. District Court for the Southern District of Mississippi

Putative class action alleging violations of Section 1983 and the Fourth and Fourteenth Amendments

Testimony regarding regression methodologies, measurement error, and data science

Retained by Latoya Brown et al.

Report filed on July 2, 2018

Martin Dulberg et al. v. Uber Technologies, Inc. and Rasier, LLC
U.S. District Court for the Northern District of California

Putative class action alleging breach of contract

Testimony regarding heterogeneity in damages across putative class members

Retained by Uber Technologies, Inc.

Supplemental report filed on June 28, 2018

Affirmative report filed on January 11, 2018

In re: Part 60 RMBS Put-Back Litigation
Supreme Court of the State of New York, County of New York

Mortgage-backed securities case

Testimony regarding sampling and statistical methods

Retained by Morgan Stanley Mortgage Capital Holdings LLC

Report filed on June 22, 2018

In Re: RFC and ResCap Liquidating Trust Litigation
U.S. District Court for the District of Minnesota and
U.S. Bankruptcy Court for the Southern District of New York

Mortgage-backed securities case

Testimony regarding sampling, damages, and statistical concepts

Retained by Advanced Financial Services, BMO Harris Bank, Cadence Bank, Colonial Savings, CTX Mortgage, Decision One, First Guaranty, Freedom Mortgage, Home Loan Center, HSBC Mortgage, Impac Funding, PNC, Provident, Standard Pacific, Synovus, and Universal American

Report filed on June 14, 2018

Deposed on April 24, 2018

Rebuttal to supplemental disclosure filed on February 26, 2018

Rebuttal report filed on October 27, 2017

Tri-City, LLC; Endor Car and Driver, LLC; Zehn-NY, LLC; Zwei-NY, LLC; Abatar, LLC; and Flatiron Transit, LLC v. New York Taxi and Limousine Commission and Meera Joshi
Supreme Court of the State of New York, County of New York

- Article 78 proceeding challenging an administrative ruling
- Testimony regarding mismatch between accessibility regulation and accessibility demand
- Retained by plaintiffs
- Supplemental report filed on May 18, 2018
- Affirmative report filed on April 13, 2018

Federal Home Loan Bank of Boston, v. Ally Financial, Inc., et al.
Superior Court of the State of Massachusetts, Business Litigation Session, Suffolk County

- Mortgage-backed securities case
- Testimony regarding sampling and statistical methods
- Retained by Morgan Stanley
- Rebuttal report filed on May 17, 2018

Cheryl Phipps and Shawn Gibbons v. Wal-Mart Stores, Inc.
United States District Court for the Middle District of Tennessee

- Putative class action alleging discrimination in employment
- Testimony regarding the decentralized nature of Walmart's internal labor market and concomitant heterogeneity across proposed class members in pay and promotion outcomes
- Retained by Walmart
- Deposed on April 30, 2018
- Rebuttal report filed on April 20, 2018

People of the State of California v. Morgan Stanley & Co.
Superior Court of the State of California, County of San Francisco

- Mortgage-backed securities case
- Testimony regarding sampling and statistical methods
- Retained by Morgan Stanley & Co.
- Deposed on February 9, 2018
- Rebuttal report filed on January 25, 2018

Tony Dickey and Paul Parmer et al. v. Advanced Micro Devices, Inc.
U.S. District Court for the Northern District of California

- Putative class action alleging false advertising
- Testimony regarding availability of information regarding and market for computer chips and heterogeneity across putative class members
- Retained by Advanced Micro Devices
- Rebuttal report filed on January 26, 2018

Federal Home Loan Bank of Chicago v. Banc of America Funding Corporation, et al.
Circuit Court of Cook County, Illinois, County Department, Chancery Division

- Mortgage-backed securities case
- Testimony regarding sampling, regression, and statistical methods
- Retained by Morgan Stanley
- Deposed on December 14, 2017
- Rebuttal report filed on August 21, 2017

In re Lehman Brothers Holdings, Inc., et al., Debtors
U.S. Bankruptcy Court for the Southern District of New York
- Mortgage-backed securities case
- Testimony regarding sampling, resampling methods for inference, and statistical methods
- Retained by Lehman Brothers Holdings, Inc.
- Deposed on October 9, 2017
- Rebuttal report filed on August 28, 2017

Deutsche Bank National Trust Company v. Morgan Stanley Mortgage Capital Holdings LLC
U.S. District Court for the Southern District of New York
- Mortgage-backed securities case
- Testimony regarding sampling and statistical methods
- Retained by Morgan Stanley Mortgage Capital Holdings LLC
- Deposed on March 27, 2017
- Rebuttal report filed on December 16, 2016

Rosen v. Uber Technologies, Inc.
U.S. District Court for the Northern District of California
- Putative class action regarding false advertising
- Testimony regarding economics of safety
- Retained by Uber Technologies, Inc.
- Deposed on February 3, 2017
- Rebuttal report filed on January 13, 2017
- Affirmative report filed on December 2, 2016

Blackrock Allocation Target Shares: Series S Portfolio, et al., v. Wells Fargo Bank, N.A.; Royal Park Investments SA/NV v. Wells Fargo Bank, N.A., as Trustee; National Credit Union Administration Board, et al., v. Wells Fargo Bank, N.A.; Phoenix Light SF Limited, et al., v. Wells Fargo Bank, N.A.; and Commerzbank AG v. Wells Fargo Bank, N.A.
U.S. District Court for the Southern District of New York
- Mortgage-backed securities case
- Testimony regarding sampling and statistical methods
- Retained by Wells Fargo Bank
- Report filed on January 18, 2017

LA Taxi Cooperative, Inc. et al. v. Uber Technologies, Inc.
U.S. District Court for the Northern District of California
- False advertising case
- Testimony regarding economics of safety
- Retained by Uber Technologies, Inc.
- Rebuttal report filed on January 13, 2017
- Affirmative report filed on November 18, 2016

State of Illinois v. Hitachi Ltd., et al.
Circuit Court of Cook County, Illinois, County Department, Chancery Division
- Antitrust price-fixing case
- Testimony regarding liability and damages
- Retained by Hitachi Ltd.
- Report filed on November 11, 2016

In re: City of San Bernardino, California, Debtor
U.S. Bankruptcy Court, Central District of California, Riverside Division

Municipal bankruptcy case

Testimony regarding economics, econometrics, rare risks and the value of a statistical life

Retained by the City of San Bernardino

Report filed on October 3, 2016

U.S. Bank National Association v. Morgan Stanley Mortgage Capital Holdings LLC
Supreme Court of the State of New York, County of New York

Mortgage-backed securities case

Testimony regarding sampling and statistical methods

Retained by Morgan Stanley Mortgage Capital Holdings LLC

Deposed on September 10, 2016

Report filed on June 17, 2016

National Credit Union Administration Board v. RBS Securities, Inc.
U.S. District Court for the Central District of California &
U.S. District Court for the District of Kansas

Mortgage-backed securities case

Testimony regarding sampling and statistical methods

Retained by RBS Securities

Deposed on January 28, 2016

Report filed on October 16, 2015

Temple-Inland, Inc., v. Thomas Cook, et al.
U.S. District Court for the District of Delaware

Escheat law case

Testimony regarding sampling, statistical methods, and economic theory

Retained by the State of Delaware

Deposed on November 24, 2015

Report filed on October 23, 2015

National Consumer Protection Service v. Farmacias Cruz Verde S.A. et al.
Honorable Civil Court of Santiago (Chile)

Antitrust putative class action

Testimony regarding appropriate methods for estimating damages

Retained by Salcobrand

Report filed on November 14, 2015

Douglas O'Connor, et al., v. Uber Technologies, Inc.
U.S. District Court for the Northern District of California

Putative class action regarding independent contractor versus employee

Testimony regarding heterogeneity in alleged damages across putative class members, potential for class conflict

Retained by Uber Technologies, Inc.

Report filed on October 27, 2015

Report filed on July 7, 2015

Students for Fair Admissions, Inc. v. President and Fellows of Harvard College
U.S. District Court for the District of Massachusetts

Discovery dispute in affirmative action case

Testimony regarding necessary inputs into statistical methodologies

Retained by Harvard College

Report filed on July 30, 2015

Securities and Exchange Commission v. James V. Mazzo and David L. Parker
U.S. District Court for the Central District of California

Civil insider trading suit

Testimony regarding probability theory and statistics

Retained by James V. Mazzo and David L. Parker

Deposed on May 13, 2015

Report filed on March 13, 2015

In re: City of Stockton, California, Debtor
U.S. Bankruptcy Court, Eastern District of California

Municipal bankruptcy suit

Testimony regarding economic theory, labor economics, and econometrics

Retained by the City of Stockton

Deposed on March 13, 2013

Report filed on February 15, 2013

In the Matter of Act 111 Interest Arbitration Between Commonwealth of Pennsylvania and Pennsylvania State Troopers Association

Hearings on wage setting

Testimony regarding rare risks and the value of a statistical life

Retained by the Pennsylvania State Troopers Association

Testimony given on December 4, 2012

Report filed on December 4, 2012

Scholarship on Sampling, Statistics, and Econometrics

Conservative Tests Under Satisficing Models of Publication Bias (with Garret Christensen and Daniele Fanelli)
PLOS One, Volume 11, Number 2, February 22, 2016

New Evidence on the Finite Sample Properties of Propensity Score Matching and Reweighting Estimators (with Matias Busso and John DiNardo)
Review of Economics and Statistics, Volume 96, Number 5, December 2014

Incomes in South Africa Since the Fall of Apartheid (with Murray Leibbrandt and James Levinsohn)
Journal of Globalization and Development, Volume 1, Issue 1, January 2010

Manipulation of the Running Variable in the Regression Discontinuity Design: A Density Test
Journal of Econometrics, Volume 142 , Issue 2, February 2008

Scholarship on Risk and Crime

Are U.S. Cities Underpoliced? Theory and Evidence (with Aaron Chalfin)
Review of Economics and Statistics, Volume 100, Issue 1, March 2018, 167–186

Criminal Deterrence: A Review of the Literature (with Aaron Chalfin)
Journal of Economic Literature, Volume 55, Number 1, March 2017, 5–48 (lead article)

The Deterrence Effect of Prison: Dynamic Theory and Evidence (with David S. Lee)
Advances in Econometrics, Volume 38, 2017, editors Matias D. Cattaneo and Juan Carlos Escanciano
2018 Emerald Literati Award, Outstanding Author Contribution

Do Sexually Violent Predator Laws Violate Double Jeopardy or Substantive Due Process: An Empirical Inquiry (with Tamara Lave)
Brooklyn Law Review, Volume 78, Summer 2013, Number 4, 1391–1439

General Equilibrium Effects of Prison on Crime: Evidence From International Comparisons (with Sarath Sanga)
Cato Papers on Public Policy, Volume 2, 2012

Controlling Crime: Strategies and Tradeoffs (co-edited with Phil Cook and Jens Ludwig), Chicago: University of Chicago Press, 2011.

Scholarship on Competition

Measuring Benchmark Damages in Antitrust Litigation (with Daniel L. Rubinfeld)
Journal of Econometric Methods, Volume 3, January 2014

Scholarship on Finance

Dark Trading at the Midpoint: Pricing Rules, Order Flow, and Price Discovery (with Robert Bartlett)
Accepted, *Journal of Law, Finance, and Accounting*

How Rigged Are Stock Markets?: Evidence from Microsecond Timestamps (working paper, 2016, with Robert Bartlett)

Shall We Haggle in Pennies at the Speed of Light or in Nickels in the Dark?: How Minimum Price Variation Regulates High Frequency Trading and Dark Liquidity (working paper, 2015, with Robert Bartlett)

Scholarship on Labor Economics

Unmarked? Criminal Record Clearing and Employment Outcomes (with Jeffrey Selbin (lead author) and Joshua Epstein)
Journal of Criminal Law and Criminology, Volume 108, Number 1, 2017 (lead article)

The Effect of Female Education on Fertility and Infant Health: Evidence from School Entry Laws Using Exact Date of Birth (with Heather Royer)
American Economic Review, Volume 101, Number 1, February 2011

Comment on "Free to Punish? The American Dream and the Harsh Treatment of Criminals", by Rafael di Tella and Juan Dubra
Cato Papers on Public Policy, Volume 1, 2011

Dynamic Perspectives on Crime
in *Handbook of the Economics of Crime*, Chapter 4, Edward Elgar, 2010

The Effect of Court-Ordered Hiring Quotas on the Composition and Quality of Police
American Economic Review, Volume 97, Number 1, March 2007

Using Electoral Cycles in Police Hiring to Estimate the Effect of Police on Crime: Comment
American Economic Review, Volume 92, Number 4, September 2002

Other Scholarship

The Ph.D. Rises in American Law Schools, 1960-2011: What Does It Mean for Legal Education? (with Joy Milligan and James Phillips)
Journal of Legal Education, Volume 65, Number 543, Spring 2016

Following Germany's Lead: Using International Monetary Linkages to Estimate the Effect of Monetary Policy on the Economy (with Julian di Giovanni and Till von Wachter)
Review of Economics and Statistics, Volume 91, Number 2, May 2009

Other Activities

2017– Member, Board of Directors, American Law and Economics Association

2007– Co-Director (with Phil Cook and Jens Ludwig), *Crime Working Group*, National Bureau of Economic Research

2009–2014 Co-Director, *Law and Economics Program*, University of California, Berkeley

Courses Taught

Columbia

2018-2019 L6916: Litigation, Economics, and Statistics (Fall); L6231: Corporations (Spring)

2017-2018 L6231: Corporations (Fall)

Berkeley

2016-2017 Law 244.4: Litigation and Statistics (Fall); Law 216: Law and Economics Workshop (Fall); Law 218.6: Law and Economics of Discrimination (Fall)

2015-2016 Law 250: Business Associations (Fall); Law 244.4: Litigation and Statistics (Fall); Letters and Science 39D: Race, Policing, and Data Science (Fall)

2014-2015 Law 250: Business Associations (Fall); Law 250S: Business Associations (Summer)

2013-2014 Law 250S: Business Associations (Summer)

2012-2013 Law 250: Business Associations (Fall); Law 250S: Business Associations (Summer); Law 209.3: Introductory Statistics (Fall)

2011-2012 Law 250: Business Associations (Fall); Law 250S: Business Associations (Summer); Law 209.3: Introductory Statistics (Fall); Law 251.31: Introduction to Law, Economics, and Business (Spring); Legal Studies 145: Law and Economics I (undergraduate)

2010-2011 Law 250: Business Associations (Fall); Law 250S: Business Associations (Summer); Law 216: Law and Economics Workshop (Fall and Spring); Legal Studies 145: Law and Economics I (undergraduate); Law 209.6: Topic in Quantitative Methods (JSP); Econ 250C: Labor Economics (graduate, shared course with 209.6)

2009–2010 Law 216: Law and Economics Workshop (Fall and Spring); Law 209.32: Quantitative Methods II (JSP)

2008–2009 Legal Studies 145: Law and Economics I (undergraduate); Law 209.3: Quantitative Methods I (JSP); Law 209.32: Quantitative Methods II (JSP)

2007–2008 Legal Studies 145: Law and Economics I (undergraduate); Law 209.3: Quantitative Methods I (JSP)

Michigan

Introduction to Quantitative Methods (policy), First Econometrics Field Course (economics), Advanced Economic Theory (policy)

Grants and Fellowships

2007–2010 NIH, Constructive Proposals for Dealing With Attrition (with John DiNardo)

2009 Committee on Research, Junior Faculty Research Grant, UC Berkeley

2006–2009 NIH, The Effect of Female Education on Fertility and Infant Health (with Heather Royer, Grant # R03 HD051713)

2006–2011 NSF, New Instrumental Variables Estimates of the Effects of Schooling and Military Service: Empirical Strategies Using Non-Public-Use Data (with Josh Angrist and Stacey Chen)

2005 RWJ Foundation Health and Society Scholars Program, Small Grant Program

2004 Rackham Interdisciplinary Grant, University of Michigan

2004 CLOSUP Grant, University of Michigan

2004 National Poverty Center Grant, University of Michigan

2002–2003 Chancellor's Dissertation Year Fellowship, UC Berkeley

Presentations

2017–2018 Columbia University, School of Law; Georgetown University, School of Law

2016–2017 George Mason University, School of Law; University of Michigan, Economics Department (Summer, Fall); Equities Leaders Summit; University of Zürich, Department of Economics; ETH (Swiss Federal Institute of Technology) Zürich, Law and Economics; Northwestern University, School of Law; Duke University, School of Law; Duke University, Information Initiative

2015–2016 Goldman Sachs; University of California, Berkeley, School of Law; University of Virginia, School of Law; University of California, Irvine; Equal Employment Opportunity Commission; National Bureau of Economic Research, Summer Institute

2014–2015 Duke University; Federal Reserve Bank of New York; Equal Employment Opportunity Commission (EEO-DataNet); American Law and Economics Association (discussant); New York University (NYU / Penn Law and Finance Conference); National Bureau of Economic Research, Summer Institute (discussant)

2013–2014 University of Southern California, School of Law; London School of Economics; Bank of Spain; CEMFI; Carlos III; University of Zaragoza; University of Rotterdam; University of Maastricht; University of Götenborg

2012–2013 University of California, Los Angeles, School of Law

2011–2012 University of Oregon, Department of Economics; University of British Columbia, Department of Economics; Brown University, Department of Economics; University of Rochester, Department of Economics; Cato Institute; National Bureau of Economic Research, Summer Institute; Harvard Law School

2010–2011 Northwestern, School of Law; University of Wisconsin, Department of Economics; Brookings Institution; Cato Institute

2009–2010 University of Chicago, School of Law; Cornell University, School of Law and Department of Economics; University of Michigan, School of Law and Department of Economics; University of Virginia, School of Law, Olin Conference

2008–2009 University of California, Los Angeles, School of Law; University of Arizona, School of Law and Department of Economics; Stanford University, School of Law and Department of Economics; University of Miami, Department of Economics

2007–2008 Northwestern University, School of Law; University of Michigan, Department of Economics; National Bureau of Economic Research, Summer Institute; Florida State University

Prior to 2007–2008, presentations are at departments of economics, unless otherwise noted

2006–2007 University of Michigan, Program in Survey Methodology; Public Policy Institute of California; Brown University

2005–2006 University of Michigan; University of California, Irvine; University of California, Santa Barbara; University of California, Santa Cruz; California State University, Long Beach; University of Western Ontario; University of Toronto; University of Illinois, Chicago; University of Chicago, Graduate School of Business; APPAM; University of Florida; University of California, Berkeley, School of Law; Princeton University; RAND; Hebrew University (conference in honor of Reuben Gronau); Stanford University, University of Wisconsin, Madison; Northwestern University; Crime and Economics Summer Workshop, University of Maryland

2004–2005 Federal Reserve Bank of Chicago; University of Illinois, Urbana-Champaign; University of Michigan, William Davidson Institute; University of Maryland; Urban Institute; American Economics Association Meetings; City University of New York Health Economics Seminar; University of Wisconsin, Madison; Stanford University; University of California, Davis; University of California, Berkeley, Labor Lunch; NBER Summer Institute, Education/Labor Studies

2003–2004 University of Michigan; APPAM; NBER Labor Studies Meeting (Fall); Massachusetts Institute of Technology; Harvard University, Kennedy School; University of California, Los Angeles; University of California, San Diego; Columbia University; University of California, Berkeley; NBER Summer Institute, Monetary Policy; NBER Summer Institute, Labor Studies

2002–2003 University of California, San Diego; University of California, Los Angeles; RAND Institute; University of Chicago, Graduate School of Business; University of Chicago, Harris School of Public Policy; University of Michigan, Ford School of Public Policy; Columbia University; Dartmouth College; Federal Reserve Bank of New York; Boston University

Last updated: October 23, 2018

Appendix B

Documents Considered List by Professor Justin McCrary

IN RE Foreign Exchange Benchmark Rates Antitrust Litigation

Document Title, Bates Numbers	Document Date

Bates Stamped Documents

BARC-FX-CIV-00019697.

CITI-FX-CIVIL-00103484 [CITI-FX-CIVIL-MS_00006374].

CITI-FX-CIVIL-00263185 [CITI-FX-CIVIL-MS_00231758].

CITI-FX-CIVIL-00263197 [CITI-FX-CIVIL-MS_00231770].

CS-FXLIT-05902054.

DB-0780117.

GS-FX-CIVIL-02190202.

GS-FX-CIVIL-02215707.

GS-FX-CIVIL-02388935.

GS-FX-CIVIL-02663202.

GS-FX-CIVIL-02809412.

HBEU-FXLITIG-00041559.

RBS-IN-RE-FX-LITIG-00027971.

UBS-ZINC-CIV-000269485.

Books

Buonaccorsi, John P., *Measurement Error: Models, Methods and Applications* (Boca Raton, FL: Chapman & Hall/CRC), 2010.

Carroll, Raymond, et al., *Measurement Error in Nonlinear Models: A Modern Perspective*, Second Edition (Boca Raton, FL: Chapman & Hall/CRC), 2006.

Clelland, Richard C., et al., *Basic Statistics with Business Applications*, First Edition (New York, NY: John Wiley and Sons, Inc.), 1966.

Cochran, William G., *Sampling Techniques*, Third Edition (New York, NY: John Wiley & Sons, Inc.), 1977.

Freedman, David, et al., *Statistics,* Fourth Edition (New York, NY: W.W. Norton and Company, Inc.), 2007.

Fuller, Wayne A., *Measurement Error Models* (Hoboken, NJ: John Wiley & Sons, Inc.), 1987.

Gilovich, Thomas, ed., Dale Griffin, ed., and Daniel Kahneman, ed., *Heuristics and Biases, The Psychology of Intuitive Judgement* (Cambridge, MA), 2002.

James, Jessica, ed., Marsh, Ian W., ed., and Sarno, Lucio, ed., *Handbook of Exchange Rates* (John Wiley & Sons, Inc.), 2012.

National Research Council, *Reference Manual on Scientific Evidence,* Third Edition (Washington, D.C., The National Academies Press), 2011.

Newbold, Paul, *Statistics for Business and Economics*, Second Edition (Englewood Cliffs, NJ: Prentice Hall), 1988.

Document Title, Bates Numbers	Document Date

Stock, James H., and Mark W. Watson, *Introduction to Econometrics*, Third Edition, Boston: Pearson Education, Inc., 2015.

Thompson, Steven K., *Sampling*, Third Edition (Hoboken, NJ: John Wiley & Sons, Inc.), 2012.

Weil, Roman L., ed., Frank, Peter B., ed., Kreb, Kevin D., ed., and Wagner, Michael J., ed., *Litigation Services Handbook, The Role of the Financial Expert,* Fourth Edition (Hoboken, NJ: John Wiley & Sons, Inc.), 2010.

Depositions

Deposition of Robin Poynder.	September 27, 2018
Deposition of Hal J. Singer, Ph.D.	September 27, 2018
Deposition of John Callaghan.	August 6, 2018

Expert Reports

Expert Report of Robin Poynder (Bank Chats).	May 31, 2018
Expert Report of Robin Poynder (Bank Data).	May 31, 2018
Expert Report of Hal J. Singer.	May 31, 2018
Expert Report of Geir Hoidal Bjonnes and Alexander Ljungqvist.	May 31, 2018
Expert Report of Keith Underwood.	October 25, 2018

Journals

Bryant, Fred B., Jennifer Howard Brockway, "Hindsight Bias in Reaction to the Verdict in the O.J. Simpson Criminal Trial," *Basic and Applied Social Psychology*, Vol. 19, No. 2, 1997.

Campbell, Jennifer D., and Abraham Tesser, "Motivational Interpretations of Hindsight Bias: An Individual Difference Analysis," *Journal of Personality*, Vol 51, No. 4, 1983.

Chalfin, Aaron, and McCrary, Justin, "Are U.S. Cities Underpoliced? Theory and Evidence," *The Review of Economics and Statistics*, Vol. 100, No. 1, 2018.

Christensen-Szalanski, Jay J.J., and Cynthia Fobian Willham, "The Hindsight Bias: A Meta-analysis," *Organizational Behavior and Human Decision Processes*, Vol. 48, 1991.

DiNardo, John, and David S. Lee, "Program evaluation and research designs," *Handbook of Labor Economics*, Vol. 4A, 2011.

Fischhoff, Baruch, "Hindsight ≠ Foresight: The Effect of Outcome Knowledge on Judgement Under Uncertainty," *Journal of Experimental Psychology: Human Perception and Performance*, Vol. 1, No. 3, 1975.

Fischhoff, Baruch, and Ruth Beyth, "'I Knew It Would Happen' Remembered Probabilities of Once-Future Things," *Organizational Behavior and Human Performance*, Vol. 13, 1975.

Fischhoff, Baruch, "Perceived Informativeness of Facts," *Journal of Experimental Psychology: Human Perception and Performance*, Vol. 3, No. 2, 1977.

Hausman, J.A., et al., "Misclassification of the Dependent Variable in a Discrete-Response Setting," *Journal of Econometrics*, Vol. 87, 1998.

Hawkins, Scott A., and Reid Hastie, "Hindsight: Biased Judgements of Past Events After the Outcomes Are Known," *Psychological Bulletin*, Vol. 107, No. 3, 1990.

Document Title, Bates Numbers	Document Date

Lamal, P.A., "On the Importance of Replication," *Journal of Social Behavior and Personality*, Vol. 5, No. 4, 1990.

Leary, Mark R., "Hindsight Distortion and the 1980 Presidential Election," *Personality and Social Psychology Bulletin*, Vol. 8, No. 2, 1982.

Powell, Jack L., "A Test of the Knew-It-All-Along Effect in the 1984 Presidential and Statewide Elections," *Journal of Applied Social Psychology*, Vol. 18, No. 9, 1988.

Rime, D., and Andreas Schrimpf, "The Anatomy of the Global FX Market Through the Lens of the 2013 Triennial Survey," 2013.

Stephan, Frederick F., "Stratification in Representative Sampling," *Journal of Marketing,* Vol. 6, No. 1, 1941.

Synodinos, Nicolaos E., "Hindsight Distortion: 'I Knew-It-All Along and I Was Sure About It'," *Journal of Applied Social Psychology*, Vol. 16, No. 2, 1986.

Walter, S. D. and L.M. Irwig, "Estimation of Test Error Rates, Disease Prevalence and Relative Risk form Misclassified Data: A Review," *Journal of Clinical Epidemiology*, Vol. 41, No. 9, 1988.

Wood, Gordon, "The Knew-It-All-Along Effect," *Journal of Experimental Psychology: Human Perception and Performance*, Vol. 4, No. 2, 1978.

Legal Pleadings

In re Foreign Exchange Benchmark Rates Antitrust Litigation, Third Consolidated Amended Class Action Complaint.	June 3, 2016
In re Foreign Exchange Benchmark Rates Antitrust Litigation, Opinion and Order.	September 20, 2016
In re Foreign Exchange Benchmark Rates Antitrust Litigation, Memorandum of Law in Support of Plaintiffs' Motion for Class Certification.	May 31, 2018
The Erica P. John Fund, Inc., On Behalf of Itself and All Others Similarly Situated v. Halliburton Company and David J. Lesar, Memorandum Opinion and Order.	July 25, 2015

Others

Robin Poynder Production, "Sample_Days.r."

Robin Poynder Production, "2018.5.31 Poynder Aggregate Summary of Chat Analysis.xlsx."

Robin Poynder Production, "2018.5.31 Poynder Daily Chat Summaries and Content."

Robin Poynder Production "Unique Employees.csv"

Robin Poynder Production "bank_mapping.csv"

Robin Poynder Production "euromoney_global_market_share.csv"

Robin Poynder Production "euromoney_global_source.xlsx"

Robin Poynder Production "euromoney_output.R"

Robin Poynder Production "euromoney_us_market_share.csv"

Robin Poynder Production "euromoney_us_source.xlsx"